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Will Using a Constructivist Approach Improve Laboratory Work for Phase 6 Electrical Apprentices?

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A thesis submitted to the Dublin Institute of Technology in part fulfilment of the requirements for the award of Masters (M.A.) in Third Level Learning and Teaching

by

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Declaration

I hereby certify that the material which is submitted in this thesis towards award of the **Masters (M.A.) in Third Level Learning and Teaching** is entirely my own work and has not been submitted for any academic assessment other than part-fulfilment of the award named above.

Signature of candidate:………………………………………..

Date:……………………………..

Abstract

This study used action research to implement a constructivist approach in the delivery of the electronics and measurements laboratory classes for a phase six group of electrical apprentices in the Electrical Services Engineering Department of the Dublin Institute of Technology. The aim of the study was to investigate if the constructivist approach adopted, with a research group, could improve the effectiveness of the two labs.

The research group consisted of sixteen, phase six, male electrical apprentices for both the electronics and measurements labs. The students ranged in ages between eighteen and twenty five years of age and were a randomly selected cohort. The research was carried out over a standard ten week block release course as part of the Standards Based Apprenticeship scheme.

A literature review was carried out covering three main areas of interest; practical work in laboratories; constructivism; and action research. These three areas were used to inform the research process and to identify a suitable methodology and methods of data collection. These methods consisted of a questionnaire to all phase six groups in the department at the time of the study, the control group; a recorded focus group; lab feedback sheets; recorded individual interviews; a reflective research journal; and examination results. Two cycles of action research were carried out.

The first cycle of action research was five weeks in duration and used an investigation type approach to solving problems on topics relevant to the labs. Following discussions with the group in week five, a different approach was agreed for cycle two. This second cycle was four weeks in duration and followed a format of carrying out standard exercises in the lab but were immediately followed by in-depth group discussions on the outcomes of the exercises and the data collected.

The findings show that the students found the investigation type approach difficult to engage with as it required a level of self-directed learning not normally used on the course. The in-depth discussions of cycle two were more effective in linking the theory and practical aspects of the lab work. The conclusions are that a student centred constructivist approach for the labs can be effective provided it does not remove all the formal structures and students are allowed time to adapt to the new format. It is recommended that this type of approach be introduced into phase four so that students have a longer exposure to the approach used and can develop the necessary cognitive skills required.

Acknowledgments

This study was undertaken with the help and co-operation of many people. I would like to express my thanks to all those involved.

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The essential partners in this study were the phase six students of the research group who gave their co-operation and views in an honest and open way. Without their help this study could not have taken place and I am grateful for their participation.

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Abbreviations

DIT	Dublin Institute of Technology.
ESB	Electricity Supply Board.
FÁS	Foras Áiseanna Saothair.
FETAC	Further Education and Training Awards Council.
NCC	National Craft Certificate.
NQAI	National Qualifications Authority of Ireland.
SBA	Standards Based Apprenticeship.
UNESCO	United Nations Educational, Scientific and Cultural Organisation.
VET	Vocational Education and Training

CHAPTER ONE

Introduction to Research

1.1 Introduction

This research study has been undertaken to investigate if the effectiveness of the measurements and electronics laboratories (labs) for phase six electrical apprentices in the Dublin Institute of technology (DIT) can be improved. The main focus of the study is to evaluate if a constructivist approach to the delivery of the labs can have a beneficial effect on the learning that takes place in these classes. For some time I have been dissatisfied with the perceived outcomes of the practical work of the labs. This unease has manifested itself since I have undertaken the Post Graduate Certificate and Diploma courses, in Third Level Learning and Teaching, run by the Learning and Teaching Centre in the DIT. This has led me to reflect on my own teaching practice, and in particular the teaching methods employed for the measurements and electronics labs. I have learned that there are other methods of facilitating student learning, which may be more effective than that which is used at the moment. I have come to believe that a constructivist approach could be a way forward for improving the practical work in the labs.

There is a great deal of literature that deals with the topics of practical lab work and constructivism and this will be reviewed in chapter 2. Using a constructivist approach for lab work is not unusual but little exists in the literature that relates directly to apprentices in general and to phase six apprentices in particular. It is hoped that this study will add to that relatively small body of literature on apprenticeship learning. Action research is the methodology that will be used to carry out this study. By following the cycles of action as outlined by Elliott (1981) it should be possible to introduce changes to the delivery of the labs and allow evaluation and reflection to take place. This will be a learning experience for both the students and myself, as one of their lecturers.

1.2 Aims and Objectives

The aim of this research is to discover if the time spent conducting laboratory work for phase six electrical apprentices in Measurements and Electronics can be made more effective, by using a constructivist approach to design and deliver a new format for the labs.

Constructivism refers to the principle that all learning is constructed by learners. It builds on previous memories and experience, and then new information is used to adapt old meanings and construct new meanings from it. A person can construct a model of reality, in a personal and subjective way, from what a person knows and this model will change and evolve as a person's knowledge and experience evolves. Knowledge does not exist separate from knowers (Tobin, 1993) but is seen as a set of socially negotiated understandings of the events and phenomena that the universe has experienced. This knowledge is accepted as viable because it fits with experience and other understandings. It can change over time because of changes in experiences and technology can bring about these new experiences. Knowledge is both social and individual, a dialectical relationship between the social contribution to knowledge and the individual's contribution. A person constructs their own environment and it includes those with whom they interact. This interacting with other people can bring about learning but this learning can also be constrained by them. Constructivism can involve investigations and group work and allow students to direct their own learning. Tobin (1993, p.7) states:

> *Typically, the teacher takes account of what students know, maximizes social interaction between learners such that they can negotiate meaning, and provide a variety of sensory experiences from which learning is built.*

He then argues that this can be a very restrictive view of what constructivism is about and reduces it to a set of methods in classrooms rather than a set of intellectual referents for making decisions in relation to actions. Constructivism can be used as a critical reflective tool to allow teachers to plan and implement strategies to suit the needs of students in a given set of circumstances and this is crucial to the design of this study.

The format of delivery of the labs can be changed so that students can see how new knowledge can be related to previous knowledge. The first priority is to understand the current situation and then examine ways of dealing with the problems without making rash decisions. Once changes have been made they can then be evaluated from feedback provided by the students.

Due to the lack of summative or formative assessment, it is difficult to provide definitive answers about the effectiveness of the labs. The effectiveness of practical laboratory work, in schools, has been reviewed by Hodson (1990) under the headings of motivation, acquisition of skills, learning scientific knowledge, and methods of science. His study indicates that the effectiveness of practical work in these areas falls far short of expectations. This also appears to be the case with phase six apprentices. The general consensus of opinion among the lecturers on the phase six course, that I have consulted with, is that the classes are necessary but there is no data to support this opinion. I would like to provide data that can be used to support, or indeed, refute this opinion.

The expected outcomes of the research are to:

- Establish the current situation in relation to the effectiveness of the labs
- Devise methods to collect data to measure changes to lab delivery and operation
- Increase students' awareness of underlying principles of particular topics while carrying out the related experiments
- Increase motivation of students in the labs by using a constructivist approach in their delivery

- Use problems encountered in work situations to generate group discussions and allow students to choose exercises to validate their answers
- Increase student participation in the labs
- Justify the continued use of the labs

The data collected during this research will be used to draw conclusions as to whether the aim has been achieved; the outcomes met and to make recommendations for the future of the lab classes.

1.3 Context

FÁS is the state run body that is responsible for apprentice education in the Republic of Ireland. The structure of the Standards Based Apprenticeship (SBA) scheme is outlined on the FÁS website under the Apprenticeship heading. Briefly, it details how FÁS co-operates with the employers, unions, The Institutes of Technology, the Department of Education & Science and the Department of Enterprise, Trade & Employment in a partnership agreement. It sets out the programme for training and the entry requirements for apprenticeship. There are seven phases, covering approximately four years, as shown below in Table 1.1.

Phase	
1	On the job training with employer (12 weeks)
2	Off the job training at a FÁS centre (20 weeks)
3	On the job training with employer
4	Off the job training at an educational college (10/11 weeks)
5	On the job training with employer
6	Off the job training at an educational college (10/11 weeks)
7	On the job training with employer

Table 1.1. Seven phases of Apprenticeship

The Irish Apprenticeship scheme is Standards Based. The apprentice must reach a set standard for each phase before progressing to the next phase. On satisfactory completion of all seven phases the apprentice is awarded the National Craft Certificate (NCC). This process normally takes four years but can be longer if the standards are not reached at the first attempt.

For phases four and six, the electrical apprentices attend an educational college, such as the DIT. The DIT is a service provider for FÁS and offers courses for both phases four and six. Both phases are of 10 or 11 weeks duration. The courses are run by the Department of Electrical Services Engineering, which is part of the Faculty of Engineering, and is based in the Kevin Street campus. There are approximately forty lecturers, including full time and part time, in the department. The department runs a three-year full time ordinary degree course in building services (FT010) and an equivalent part time evening course (K249). The remainder of courses run by the department are mainly apprentice based. Each term five phase four and ten phase six courses are offered. With an average of sixteen students per group this gives seven hundred and twenty apprentices attending each academic year. The department also offers evening courses for apprentices who need to repeat the phase four or six examinations and courses for updating skills.

During the off the job training phase, the phase four and phase six electrical apprentices cover subjects called Electrical Science and Electrical Craft Theory, as well as practical wiring workshops and an electronics and measurements lab. The apprentices are timetabled from 9.00 to 5.00 each day. It is an intensive 10-week course, with no self-study time included. As part of the course delivery, in the DIT, they spend one and three-quarter hours a week in a measurements lab and one and three-quarter hours a week in an electronics lab. The purpose of the labs is to allow the apprentices to carry out a range of set exercises that will reinforce the theoretical principles covered in the classroom. They should also allow the apprentices to safely use, and become familiar with, various measuring and testing instruments.

Despite the educationally sound aims and objectives of these types of laboratories, I have found in practice that the apprentices appear to fail to grasp the principles behind the exercises and tests. Over the four years that I have taught on these particular labs, since becoming a full time member of staff, I have observed that students do not participate well in the labs. They appear to perceive them as stand-alone pieces of work that have little, or no, connection to other parts of the course. Over these years, I have questioned them, informally, about what they have learned from the labs. They appear to have little understanding of what they were attempting to achieve or why they were doing it. Fellow lecturers have also expressed the same sentiments. Boud, Dunn and Hegarty-Hazel (1986, p.3) have commented on students' view of science laboratory work. They state: "*It is quite common to hear them say that laboratories are boring, that they go through the motions of experimentation without stimulation and often without any clear purpose*". These comments were in relation to undergraduate science students but the feelings appear to be similar to those expressed by the electrical apprentices.

1.4 Rationale

This study originated from a need to discover why the apprentice students see these labs in a manner similar to that described by Boud *et al* (1986) and why they appear to fail to engage with the subject. There is no summative assessment in the electronics and measurements labs because the curriculum only calls for formal assessment as part of the phase six national theory examinations at the end of the phase six course. As part of the electronics lab work the students must construct several circuits as detailed by the syllabus (FÁS, 2000). It is possible for students not to attend any practical classes and still perform well on the theory examination at the end of the phase six course. The standards to be achieved, as part of this practical work, are detailed in the syllabus by phrases such as "*correct circuit function; accuracy of measurement; accuracy of description of circuit operation and accuracy of plotting*" (FÁS, 2000). Feed-back on how the students perform on these exercises is only given informally. Even if students do not perform well in the labs they may still sit the theory examination. This tends to lead to the idea that the practical and theory elements are not linked.

The measurements lab, unlike the electronics lab, is not one subject in its own right. It covers several topics on the syllabus, including both electrical science and craft theory. The syllabus calls for practical work to be carried out on several topics and these practical aspects are brought together under the name of measurements lab. This includes topics such as transformers, three phase voltages and currents, tests on completed installations, and three-phase rectification. By using this format, the theory and practical aspects of the subjects are completely separate. This again may lead to the impression that there is a definite distinction between what the theory says and what is done in the practical lab. It is the concept of this linking of the two elements that I have found that the students appear to struggle with. After discussing the principles involved in the labs with the students, over many terms, it is clear to me that the labs fail to engage the interest of the students and this can lead to lack of participation by the students. This lack of participation in the labs may lead to the failure of the students to construct the links between the theory of the topics and its practical aspects. This failure would mean that one of the fundamental aims of practical work, the linking of theory and practice, is not being achieved in the labs.

Through investigating the current situation, and reaching an understanding of what occurs during the lab classes, then as the facilitator of learning of these students, I can look at ways of introducing change and measuring its impact. It is proposed to use action research to achieve this. By using an action research cycle, as described by Kurt Lewin (1946) and modified by John Elliott (1981), I will be able to implement changes to the delivery of the lab and then evaluate the results of changes to the current practice. I want to improve student learning by increasing student participation in the labs and by building on past experience of the subject area. If changes in relevance can be brought about then this may lead to better participation and learning. By following carefully considered changes and reflecting on the results, I aim to facilitate students' learning in a more structured, interactive way.

For the electronics practical work it is usual for the students to work in pairs. Working in pairs is due mainly to the capital cost investment in expensive lab equipment such as oscilloscopes, signal generators, power supplies, and multimeters. Eight sets are provided for the electronics lab. One advantage of this set-up is that all the students do the same exercise at the same time. The FÁS syllabus details the type of exercises the students must carry out. While it is possible to include other exercises, where time allows, students are very quick to relate the exercises to what is needed to cover questions that appear on the theory test. In my experience, anything that does not appear relevant to the examination is quickly discarded by the students as unnecessary and interest levels drop. This problem is not uncommon. Tobin (1993 p.12), commenting on a study of the use of assessment as a motivator, states: *"Unless an activity was assessed, it was difficult to obtain the active participation and cooperation of students".* The time constraints for the electronics lab also mean that eight sets are realistic. The time taken to check and fault find on 16 circuits is far greater than the time allocated to the lab. This has been confirmed from many years of experience. If all the circuits work first time, then time is not a problem. In practice, however, this rarely occurs. Indeed, the art of faultfinding is a very valuable skill to practice and perfect.

For the measurements lab the situation is not as favourable. Many of the transformer tests require the use of two sets of measuring instruments for each circuit. The circuits can also be somewhat complicated and time consuming from which to take readings. There are insufficient instruments to run eight sets at the same time. This is a major drawback as it means that more than one type of exercise is being carried out in the lab at the same time. To run through each exercise with the groups is time consuming and leads to problems if the circuits do not function correctly. For the measurements the students usually work in groups of four. Providing explanations and fault finding for four different exercises in the same lab demands a great deal of the lecturers' time. If delays in giving assistance occur then this can lead to reduced participation on the part of the students.

By using the action research cycles in this study, it is hoped that an approach can be developed that enables the students to engage effectively with the topics in the labs. It is important both for the students, and myself, that the labs are places of learning and not used simply to carry out exercises for the sake of doing so.

1.5 Ethical considerations

With any research, it is essential that ethical considerations be taken into account. Ethics affected many areas of this research study. It was not just a matter of confidentiality. It concerned other areas such as selecting students, types of questions asked, agreement of students to participate, storage of data from the research, anonymity, and disclosure of results to participants.

Bell (1999, p.39) quotes from Blaxter, Hughes and Tight (1996b, p.146) about summarising the principles of research ethics:

> *Research ethics is about being clear about the nature of the agreement you have entered into with your research subjects or contracts. This is why contracts can be a useful device. Ethical research involves getting the informed consent of those you are going to interview, question, observe, or take materials from. It involves reaching agreements about the uses of this data, and how its analysis will be reported and disseminated. And it is about keeping to such agreements when they have been reached.*

It was important to allow the students involved in the research to read, and understand, the form of agreement that I asked them to sign. To undertake this research, the consent of the head of department (in writing) was required. A copy of this is provided in Appendix B. I would be implementing different approaches to the delivery of particular laboratory classes. This also required the consent of the students involved. They needed to be reassured that whatever happened during the labs, it would not put them at a disadvantage to their peers who were not involved in the action research cycles of this study. I also made it clear that I would not be involved in any assessment of the students taking part in the research, for the purposes of the phase six examinations. The students were also made aware that if at any time they felt that the research was having a negative impact on their learning, the methods employed would be modified, or the research suspended, until problems could be resolved.

Another consideration was to ensure that I did not lose track of the purpose of the lab and end up so engrossed in the research that the normal learning of the lab was compromised. Peeke (1984, p.24) warns of this danger when he states:

> *To be a successful researcher can demand a lessening commitment to the task of teacher; it is ironic that a concern for quality of education may motivate a teacher to involve himself/herself in research, but can also be detrimental to a teacher's own work in the classroom.*

The general principles to be followed are detailed in the DIT's publications on ethics. The ethics committee's mission is quoted as:

(a) To provide all DIT researchers, staff and students, with the resources, understanding and addressing ethical issues which arise in their research; and

(b) To promote responsible research and practice.

The research material will only be used for the purpose stated and will not be disclosed to others except in the form used in the research documentation. The names of students involved in the research will not be used in the documentation. An ethics statement was prepared outlining the issues discussed and a copy was given to the students in the research group. A copy of this statement is provided in Appendix F.

Action research also involves many moral issues. The students involved in the research were not 'subjects' or 'objects' of the research but were participants (McNiff, 2002). The actions that I took as part of this study could have affected the students and how they progressed on the course. I had a moral duty to ensure that my actions did not in any way disadvantage them or try to impose undue pressure on them to experiment with new learning methods that they may have been uncomfortable with. These moral obligations were also part of the reflection process at the end of cycle one when the students raised issues about their progress on the course.

1.6 Summary

This chapter has explained the reasons for undertaking this study, mainly my own dissatisfaction with the effectiveness of the measurements and electronics labs and the desire to allow the students to experience alternative learning opportunities. It has examined the context of the labs in relation to the phase six apprentices, the syllabus as set out by FÁS, the objectives as detailed in that syllabus, and the use of lab work as a means of learning. The aims of the study, and the expected outcomes of using a constructivist approach for the labs, have been outlined and action research has been chosen as the methodology for this study. The ethical considerations for this study have also been outlined and the rights of the students to withdraw from the research have been detailed.

Chapter two deals with the literature under three main areas; action research, constructivism, and practical work in relation to science subjects. The literature shows how all three areas impact on this study and the importance of the action research cycles.

Chapter three outlines the theoretical perspective and the epistemological stance that underpins the research and then examines the methodology used for this study. The three main research paradigms are outlined and the reasons why action research is the methodology employed are described. The different types of action research are examined and the particular model by Elliott is detailed.

Chapter four deals with the methods used for data collection and the presentation of the findings of the research. The methods include the use of a questionnaire to all phase six apprentices during one particular term, a feedback sheet at the end of each lab session, a recorded interview with a small focus group between cycle one and cycle two of the action research stage, a research journal and recorded interviews with four individual students from the research group. This provided a mixture of both quantitative and qualitative data for analysis. The presentation of the findings includes an analysis of the questionnaire data and the qualitative data from cycles one and two of the action research. The data from the questionnaire is presented in a series of charts so that the control and research groups can be compared directly.

Chapter five presents a discussion of the findings presented in chapter four. The difficulties of the data collection and the participation of the students involved are discussed and analysed. The effectiveness of the implemented changes are examined and put into context for this particular research group and how this may relate to other apprentices.

Chapter six draws conclusions from the findings of this study and outlines recommendations for the future of the measurements and electronics labs. The benefits to myself, the apprentices, the department, and the apprenticeship scheme are also outlined.

CHAPTER TWO

Review of Literature

2.1 Introduction

This study involves the overlapping of three main areas of interest; Laboratory Practical Work, Constructivism, and Action Research. Much has been written about all three of these areas of interest. The focus of this study is in applying a constructivist approach in the electronics and measurements labs for phase six electrical apprentices, using the methodology of action research. Much of the literature in relation to practical lab work refers to second level schools in the U.K. and there is little in the area of apprenticeship. It is hoped that this study will fill this gap, especially in relation to the Standards Based Apprenticeship. By reviewing the literature it will become clear how each area impacts on this study. By understanding these three areas of interest, it should enlighten the research process and direct the researcher towards making improvements in the learning opportunities for the students in the two labs.

2.2 Laboratory Practical Work

Carrying out practical work in electronics and electrical measurements is an integral part of the phase six course (FÁS, 2000). The feedback from the questionnaire to the students, about these labs, indicated that they were unsure why they were carrying out experiments or what benefits they could derive from them. This is a common theme with practical work and has been the focus of many studies into attitudes about the aims of practical work, West (1972), Swain (1974), Thompson (1985), Hodson (1990) and

Swain *et al* (2000). Despite all of these studies, much confusion still exists about the aims and effectiveness of practical work and it has long been debated (Hodson, 1991). The questions often asked are:

- Is practical work really necessary?
- Is it effective?
- Could the time be used more constructively by using other teaching methods?

To answer these questions studies have been carried out to identify the reasons why school science teachers carry out practical work. Comparisons of studies carried out by Kerr (1963), Beatty and Woolnough (1982), and Thompson (1985), have shown that the results are very similar (Wellington, 1998). Over the three decades, the attitudes of teachers to science practical work, in schools, had not changed. When rating the reasons for doing practical work *"... teachers consistently over these thirty years rated those aims relating to developing practical skills and attitudes most highly and those related to discovering or elucidating theory much lower"* (Wellington, 1998, p.114). This was despite the fact that the type of activity had shifted emphasis from controlled exercises to discovery experiments (Beatty and Woolnough, 1982). The attitudes of science teachers were again surveyed in 1997 (Swain *et al* 1999), as part of a larger international comparison of science teachers in Korea, Egypt, and the United Kingdom. When comparing the results of attitudes in 1997 to those of science teachers in the U.K. in 1979 they stated *"Generally, it looks as though very little has changed in teachers' attitudes as to why they do practical between 1979 and 1997" (*Swain *et al*, 2000, p285). They did note that the sample size used was small and that the results were indicative of developments but not conclusive, and were of interest in documenting historical changes in science education. It is clear from these studies that very little had changed in the attitudes of science teachers to practical work and that its precise aims were still unclear. Each of the studies set out the main aims that the teachers thought were important at that particular time. Kerr (1963) listed ten main aims of practical work. Beatty and Woolnough (1982) listed twenty aims for practical work, which included the original ten listed by Kerr and ten new aims that were deemed to be important. A copy of the complete list is provided in appendix G. The survey by Swain *et al* (2000) showed that the most highly rated aims of practical work, when comparing 1979 and 1997, were:

- To encourage accurate observation
- To promote logical reasoning
- To arouse and maintain interest
- To make phenomena more real

Four further aims that showed a higher rating in 1997 than in 1979 were:

- To practice seeing problems and seeking ways to solve them
- For finding facts and arriving at new principles
- To develop an ability to cooperate
- To develop a critical attitude

This suggests that there is a trend away from the traditional set exercises to investigation and problem solving type exercises.

It is the historical changes that need to be considered when trying to understand the reasons why practical work elicits such uncertainty. It is necessary to examine its origins and the changes that have occurred over the last 170 years or so since its slow introduction. Boud *et al* (1986) have described these origins drawing on the work of Morrell (1972), Menzie (1970), and Phillips (1981). They have described how the forerunner of the laboratory practical was the lecture-demonstration. Traditionally in universities, the professors' incomes were linked to the number of students attending lectures. The lecture-demonstration was very cost effective, since the cost of the demonstrations were borne by the professors out of their own incomes, but still allowed large numbers to witness the demonstrations. There was then a slow transition to individual laboratory work. The first laboratory courses were introduced by Liebeg at Giessen and by Eton at the Rennsselaer Polytechnic Institute. In 1818 Thomas Thompson established the first undergraduate course in practical chemistry in Glasgow. The driving force for this was to emphasise that undergraduates would be engaged in observation and reasoning and this would lead to training of the mind, not just practical skills (Wellington, 1998). Individual laboratory work was slowly introduced from the 1820s onwards in Germany, Great Britain, and the United States. The first physics practicals were introduced in Oxford in 1860 and, in 1873, the first physics laboratory manual was published at the Massachusetts Institute of Technology by E.C Pickering. There were two main reasons why practical work became an integral part of such courses. The first was that student demand was being met by teachers working outside of the universities and the second was that there was a need for training in research (Boud *et al*, 1986).

Science education in schools began in the 1840s; it was justified for two main reasons. Firstly to allow learners to gain scientific knowledge so that they could do useful work and secondly, it was considered training for the mind (Layton, 1973). Again the first laboratories to appear in schools tended to be chemistry labs because of the need for storage and disposal of chemicals and the associated equipment. The design of the labs was copied from the German models due to the influence of English chemists who had trained in Germany (Brock, 1992). It was during the last quarter of the nineteenth century that significant building of science laboratories took place in the U.K and these were mainly to the design of the Department of Science and Art. In 1904 practical work in science became compulsory in grammar schools and with this increase in science practical work came the standardised laboratory manual. The standard format of writing up the experiments was: Title, Apparatus, Method, Observation, Results, and Conclusion (Wellington, 1998). This is still exactly the same format that is used in our own laboratories today.

In the U.K in the 1960s, large-scale reform took place funded largely by the Nuffield Foundation and the Schools Council. The emphasis on laboratory work changed from standard exercises to investigations, as stated by Wellington (1998, p.46);

> *They were, in short, once again to 'learn science by doing science', a doctrine that owed more at least, at the secondary level, to a reinvigoration of the historical commitment to laboratory work than it did to ideas about the importance of direct experience and discovery in children's development although these were of rhetorical significance.*

The raising of the school leaving age in the U.K in the 1970s led to greater numbers of students doing practical work and with it more confusion about the aims and assessment of practical work. Yet more reforms in the 1980s led to more reliance on individual investigations and yet more problems in assessment (Wellington, 1998). These later problems relate to second level education but it is these students who go into third level education with the concepts about what laboratory work is, already formed in their minds. Third level laboratory work, within the Dept. of Electrical Services Engineering, still uses the standard experiment methods to achieve its aims. It is clear from the literature that there are still very mixed views of how, and why, practical work should be carried out.

When I started part-time teaching over 20 years ago, I used the same methods of teaching that I had been taught by, and this is not regarded as unusual (Fosnot, 1996). Over time it became clear to me that these methods did not engage the students, especially in practical work. It was with practical classes that most part-time lecturers, in the department, started their teaching careers and the standard procedure for carrying out experiments was used. The experiment was carried out and then written up using the standard headings of Title, Apparatus, Methods, Observation, Results and Conclusions (Wellington, 1998). This format is over a hundred years old and, while it is useful for giving some structure for write-ups, I no longer believe that this format is an essential part of practical work. By insisting on formal write-ups for the experiments, it left little time in the labs for discussing the experiments. Eventually I stopped placing so much emphasis on this format and concentrated more on explaining how the experiment related to the theory. This was not part of a conscious effort to improve teaching practices but just an attempt to resolve a particular problem, nor did I use it as a form of action research. In all honesty, I had not come across the concepts or specific practice of constructivism or action research in my apprenticeship context previously. Even if I had, I would probably have dismissed them as not being relevant to my own practice because there was a standard way of teaching apprentices and it was regarded as being effective. Having spent nearly three years working towards a masters award in learning and teaching, I can see differently now. There are many different teaching approaches that can be used and I now see it as my duty to find the approach that best suits the apprentices' needs.

To find this approach I need to be aware of what type of activities I expect the students to carry out in the labs. The three main types of laboratory work that are normally carried out are stated by Boud *et al* (1986) as being:

1. Controlled exercises

   The normal format for the controlled exercise involves the student in some form of pre-laboratory activity as an introduction. This is then followed by the actual experiment itself and followed by writing up the experiment. It is very often the case that the student can successfully carry out the experiment, and obtain the results, without having any idea as to why they are doing it, or how it relates to the underlying theory.

2. Experimental Investigation

   These are generally longer activities in which the student has some choice of the experiments carried out to achieve the outcome of an inquiry. They can give students an opportunity to practice inquiry skills and can aid motivation by allowing students to build problem-solving skills.

3. Research Projects

   This form of research can be used by a student to apply skills and knowledge to a small-scale research problem. It is often used in the final year of science degree courses. Another variation of the research project is where students can join a research group to solve a particular problem.

At the moment it is the standard exercise that is used for the phase six classes. For the purposes of this study I intend to change the type of activity carried out in the labs to the second type; that of experimental investigation. The literature shows that there can be drawbacks to using this type of activity. The reforms carried out by the Nuffield Foundation and the Schools Council in the U.K. in the 1960s, introduced this type of activity into practical lab work. It was an initiative that encouraged students to pursue their own inquiries and tap into their natural curiosity. The inquiry-based approach could also encourage students to be more independent and self-reliant. By doing this it could support general educational goals (Millar, 2004). The disadvantages of this type of inquiry are that firstly, because students lack experience, they often make observations or measurements that are incorrect or imprecise. Secondly, they are unable to draw the intended conclusions from the data. Thirdly they expect the teacher to know the answer to problems and confirm what they have done is correct. It can be very difficult to draw conclusions from sets of data. "*From an educational point of view, it is the clear separation of data and explanation – and the recognition that there is no direct route from data to explanation – that is the most useful insight*" (Millar, 2004, p.4). The process and content of science needs to be integrated so that the links can be established. When implementing the investigation type of exercise into the labs I need to be aware of these drawbacks but the positive effects may be more beneficial to the students on the phase six course.

To carry out an experiment there must be an aim that the student is trying to achieve. The effectiveness of the experiment is often measured against the achievement of the aim. The same notion can be applied to practical work itself. If practical work is specified in the syllabus, then there must be aims for its existence. The surveys carried out by Kerr (1963) and Beatty and Woolnough (1982) of teachers' attitudes to practical work resulted in a list of twenty aims for practical work. The ten additional aims quoted by Beatty and Woolnough were to develop skills such as: carrying out instructions; developing a critical attitude; developing self reliance; communicating effectively; the ability to co-operate; and remembering facts and principles. These skills are very similar to those quoted by Coles (1996) in Woolnough (1998), as being the qualities desired by employers in recruits for science based work. They are also the same as some of the core and transferable skills advocated by Harford (2005) that should be developed within the SBA. The aims of practical work have now taken on a far greater role than that of simply observing an exercise. Carrying out practical work is now expected to allow students to develop a wide range of key skills and to develop these skills, the type of experiments carried out needs to suit the particular context. Simply carrying out standard exercises would not achieve this.

It is clear that not all of the aims listed by Beatty and Woolnough (1982) can be covered in any one experiment. The exact aims depend on the experiment and the context in which it is being used. Millar (2002, p.10) when discussing the effectiveness of practical work states: "*Instead we need to ask about the effectiveness of **specific** labwork tasks for achieving **specific** learning objectives*". He then proposes a model for the development of a teaching and learning activity. This can be used to judge the effectiveness of the students doing what they should be doing and also the effectiveness of them learning what they should be learning. This can only be done if the learning objectives of the practical task have been identified clearly. To help identify what these learning outcomes are he uses tables in which boxes are ticked to indicate the type of outcome for content and process. Further tables for identifying what students are intended to do with objects and then what they are intended to do with ideas, are used to make up a labwork task profile. This profile can then be used to clearly show the intended learning outcomes and the methods used to achieve them. From the tables it can be seen that there are two domains of knowledge: the domain of real objects and observable things and the domain of ideas. It is a fundamental aim of practical work to link these two domains (Millar, 2002). The labwork profile can be used to show if each individual experiment is achieving this or just concentrating on one domain only. By showing precisely what each piece of labwork is setting out to achieve, then it will be clear what the students are expected to gain from carrying out the exercise.

With regard to practical work the literature is clear about one aspect of it; the aims need to be clear. For the phase six apprentices, I probably expect too much from the exercises. The syllabus only refers to *circuit function, accuracy of measurement and accuracy of calculation* (FÁS, 2000). These are straightforward observable actions. So why do the students not engage in the activities? The idea of using only procedures in practical work is commented on by Séré (2002, p.258): "*In fact procedures are embedded in a given content, not existing on their own. They can, however, be taught for themselves, strictly with the aim of imparting skills, but always as an intrinsic part of an experimental process using theory*". My own belief, in relation to the Electronics and Measurements labs, is that the lab work is not grounded in the theory sufficiently for the students to see the relevance of the tasks. Building a circuit simply for the sake of doing it does not appear to engage the imagination of the apprentices, nor does it help in establishing the links between the data obtained and the underlying theory of the exercise. By using an investigation type activity, within a constructivist approach, it is hoped that the students will be able to build on the conceptions they already have from previous courses and engage with the topic. How exactly I can achieve this is one of the major problems. The literature, as shown in section 2.3, sets out the theories of constructivism and how the classroom should be adapted to suit this approach. It is not just the classroom where learning takes place. The laboratory also offers this opportunity. Bettencourt (1993, p.48) describes the importance of practical work thus:

> *That is, prior to activity, there has to be a question; during the activity, there has to be a reflection (the stepping back) on the difficulties encountered, and, after the activity, the accounting (to oneself, if nothing else) of what happened. Unless hands-on science is embedded in a structure of questioning, reflecting, and re-questioning, probably very little will be learned.*

At the moment this does not happen in the labs. By using this concept of posing questions, discussing problems and reflecting on what occurs during the labs it is intended to allow the students the opportunity to engage more with the topics. By using discussions, the concepts that the students hold at the moment can be clarified and by relating the exercises to the theory, these concepts can be strengthened or modified.

It is clear that practical work has traditionally been demanded by students but it does not appear to meet the expectations of the students. Teachers find that labwork does not appear to achieve what they had intended. The aims and objectives of the labwork are at the centre of the problems. The idea of targeted labwork has been suggested by Séré

(2002). The objectives are usually designated as being conceptual, procedural, and epistemological. They are, however, all intertwined. By eliciting the relationship between theory, experiment, and data processing, the labwork can be structured in a motivating way. The role of the tutor and written guidance during the labs has a great impact on the effectiveness of the labs. When both students and teachers are clear on certain selected objectives then the lab can be targeted to achieve this. By adopting this type of approach in the labs I hope that the students will engage with the topics and increase the effectiveness of the labs.

2.3 Constructivism

In this section the literature is used to show that constructivism is a very general term for learning approaches that have developed over a long period of time. These approaches are outlined in terms of how they assist learners construct knowledge and then, more specifically, how they can relate to the phase six apprentices as part of the approach to be adopted for this study. The term may be relatively new but the principles involved can be traced back many centuries to the time of Socrates. He is said to have taught others by using insightful questioning and Plato later used these same teaching techniques (Hawkins, 1994). Other early proponents of constructivist methods were Lao Tzu (6^{th} century B.C.), Buddha (5^{th} Century B.C.), Heraclitus (5^{th} century B.C.), Giambattisto Vico (18^{th} century). In more modern times, Immanuel Kant in the 18^{th} century also used constructivist theories. He said scientific knowledge is actively constructed by an observational experience. Friedrich Hayeks, a Nobel Prize winner, in his book, The Sensory Order, (1952) gave a theoretical presentation of constructivism (Mahoney, 2003). Friederich Froebel recognised the capacity of children for self directed learning, but used a very rigid system for encouraging it. Others followed and gradually removed these rigid processes and developed the participatory role of the teacher. At the turn of the 20^{th} century, John Dewey was a supporter of the constructivist movement. In 1963, in his last major work, Dewey emphasised again the role of the teacher in discovering the talent of children and using appropriate methods to introduce subject matter (Hawkins, 1994).

Constructivism refers to the principle that all learning is constructed by learners; it builds on previous memories, beliefs, and experience, and new information is used to adapt old meanings and construct new meanings from it. The way that a person constructs knowledge is particular to that person and is true to them but not necessarily to anyone else. The constructed knowledge depends on experience and since everyone's experiences differ, then the constructed knowledge can differ. Constructivism can involve investigations and group work and allow students to direct their own learning. Constructivism is not a theory of instruction but is a theory of knowledge and learning (Fosnot, 1996). This is also stressed by Tobin (1993, p. 8): *"Constructivism, as a set of beliefs about knowing and knowledge, can be used as a reference to analyse the learning potential of any situation"*.

This type of learning can be regarded as resolving inner conflicts that arise because of new experiences that appear to contradict existing models of knowledge. Modifications take place that allow the acceptance of new knowledge. The idea of constructivism moves away from the theories of behaviourism, as outlined by Skinner (1968) and Thorndike (1926). The behaviourists believe that the environment is the predominant factor in learning and that subjects will learn in response to a stimulus. If positive reinforcement is provided then this will be a happy experience for the student. Skinner also showed that occasional positive reinforcement was particularly effective with recalling information. The idea that assessment drives learning is based on this idea. Achieving good grades for assignments will reward students and encourage them to achieve more. This concept is true but it has been shown that it may lead students to be very selective in what they learn. They will only cover topics that are directly related to assessment and avoid what they consider unnecessary material. In a study by Tobin and Gallagher (1987) it was shown that students would work for grades in the same way that employees work for pay. They stated that: "*Students focused on completing tasks and getting the grade, and learning became a by product in the main activity in the culture*"

(Tobin, 1993, p.12). This type of behaviour can be seen quite clearly by the phase six apprentices when they relate everything in the labs to what questions will appear on the examination papers. Another issue in the labs is the fact that they are not assessed directly and this can lead the students to believe that the labs are not an important part of the phase six course.

There is not just one form of constructivism: terms such as radical constructivism and social constructivism are common. The term radical constructivism is generally applied to those who believe that the individual's mental world is the only reality (Schunk, 2004). Constructivism can also be viewed as an epistemology or in the words of Von Glasersfeld: *"It can therefore be considered an exercise in epistemology"* (Tobin, 1993, p.23). Constructivism does not strive to discover the real truth of a situation but strives more for viability, something that appears to work. Once a learner constructs a model of a particular concept then that becomes, in effect, the reality for that learner. This model continues to be used until a situation arises where the model no longer works. The learner is then faced with a problem where the reality of a situation must change. New knowledge is gained and the model changed or revised to adapt to this new knowledge. It is important to allow students the opportunity to construct this knowledge and it cannot be forced upon them. It must come from the students' own desire to acquire new knowledge. Von Glaserfeld (1993, p. 34) says that:

> *At best, the teacher can orient the students' constructing in a fruitful direction; she can never force it. This is, of course, time consuming, but after students have experienced the pleasure of finding a solution by their own thinking once or twice, they will be quite ready to work on problems suggested by the teacher.*

The learning process can take place in cycles, along the lines of that advocated by Atkin and Karplus (1962). By first establishing what the students know and then introducing them to new situations that can challenge the concepts they hold, the students can be exposed to new concepts and learn through this experience.

Jean Piaget viewed constructivism as a way of explaining how people come to know about their world (Brooks and Brooks, 1993). He saw the human mind as a set of cognitive structures that help us make sense of what we perceive. These structures become more complex as we grow older and gain experience of the world. Piaget suggested that the temporary cognitive stability resulting from the balance of assimilation and accommodation is called equilibrium. When confronted with an internally constructed contradiction a child needs to reach equilibrium and so constructs new cognitive structures (Brooks and Brooks, 1993). Equilibrium was described by Piaget as a dynamic process of self regulated behaviour balancing two intrinsic polar behaviours; assimilation and accommodation. Assimilation is where a person organises his experiences with reference to his own understandings. At times new experiences create contradictions that can upset the equilibrium of the structure. The person then accommodates the new experience by reflection and changes in behaviour and then this can allow the equilibrium to be restored. Equilibrium is a dynamic process, not static. When contradictions occur there are basically three choices. The first is to ignore the contradiction. The second is to hold two different theories at the same time, each working in different situations. The third is to construct a new model that resolves the contradiction. Whichever one occurs, it is due to the self organising behaviour of the learner (Fosnot, 1996).

Learning takes place by internal process of assimilation or accommodation of new experiences by the learner. This does not happen in isolation from other learners. Vygotsky believed that learning, in children, is enhanced when it is in a social context. He proposed "spontaneous" and "scientific" concepts. The spontaneous concepts arise from a child's own reflections on everyday experiences. The scientific concepts occur in the structured activities of the classroom, where more defined concepts, rather than spontaneous concepts, can be imposed on a child. He described the "zone of proximal development" as the meeting of the scientific concepts working downwards and the spontaneous concepts working upwards. Vygotsky believed that the spontaneous concepts must have reached a certain level before a child could absorb a scientific concept. Dialogue was also studied by Vygotsky and how it affected a child's learning.

The adult draws a child out to a new level of performance. The adult supports and encourages the child. The term "scaffolding" is often used to describe this interaction. Once the child reaches a certain level, the scaffolding is no longer required. Bruner (1986) also regards the scaffolding idea as important for the child to get through the zone of proximal development (Fosnot, 1996). While Vygotsky was referring to child development, the same ideas may be applied to a learning situation by any student as they progress through different levels of knowledge. The social role of constructivism is important. By discussion and debate students can come to see the points of view of others and accept the different ideas about topics. This applies to practical work also. Bettencourt (1993, p.47) states: "*The important part is not that students manipulate things physically but that they do it for a purpose and engage in discussion about it*". It is important for the phase six students to see that there are reasons why they carry out practical work and engage in discussion about it. By merely observing "*circuit function, accuracy of measurement and accuracy of calculation*", as stated in the phase six syllabus, the students are not encouraged to engage in discussion or to understand the significance of the exercise in the wider context of the syllabus or their work places. By using the problems and investigations in the labs, I will be providing the students with the opportunities to engage in this type of activity.

The individual uses cognitive processes to deal with new experiences. These experiences are usually in a social context and as such, are influenced by others. The level of influence depends on the context.

> *As ideas are shared within a community, new possibilities are suggested to the individual for consideration. These multiple perspectives may offer a new set of correspondences, and at times even contradictions, to individual constructions. Of course, these perspectives shared by others are not "transmitted"; even the shared perspectives are interpreted and transformed by the cognising individual. But as we seek to organise experience for generalizations and communication, we strive to coordinate perspectives, to "get into the head" of others, thereby constructing further reflective abstractions and developing "taken as shared" meanings.*
>
> (Fosnot, 1996, p.27)

The context of the classroom can have a huge impact on the learning of an individual. In contrast to the idea of each individual student seeing problems as their own is the idea of social constructivism. Events can be seen as occurring in a certain context. Students struggle to make sense of events and can reach a new awareness of a situation and see it as a new experience. By discussing the problem with others, the student can achieve this awareness to a greater degree than if the student worked alone. In Brooks and Brooks (1993, p.ix) there are five principles listed that should be evident in constructivist classrooms:

- Teachers seek and value their students' points of view
- Classroom activities challenge students' suppositions
- Teachers pose problems of emerging relevance
- Teachers build lessons around primary concepts and "big" ideas
- Teachers assess students learning in the context of daily teaching

By using these principles students are allowed the opportunity to construct their own knowledge from learning situations.

This is also stressed by Bettencourt (1993, p.39): "*If we agree that learning has to do with the growth of knowledge and that science is knowledge about certain domains of experience, then constructivism has relations with learning and teaching, and with science*". By designing exercises that can allow the students the opportunity to see the relevance of topics, it should encourage the students to engage more actively in the labs. By working in groups, students can discuss problems and come to conclusions that they may not have reached on their own. Collaboration can have a very positive effect on the ability to get tasks completed. By introducing these principles into the lab, it is hoped that the students will be encouraged to engage more in the activities.

My own beliefs are that constructivism is a viable approach to learning and teaching. This learning is not just in relation to the students but to myself also. Each time I take a new class I go through a learning experience. No two classes are the same because they are all made up of individuals, each with their own experiences and concepts already in place. The literature on constructivism indicates that the classroom or laboratory should be a place where students can work together, discuss ideas, discover phenomena for themselves, and most of all face challenges. The lecturer or teacher is the facilitator of this learning environment. Many specific examples of the approaches used by teachers are provided (Tobin, 1993; Fensham, Gunstone and White, 1994; Psillos and Niedderer, 2002) and they show the positive effects they can have on students. It is clear that there is no one approach that works for all situations. Each example is set in its own context with particular types of students. The challenge for me is to develop an approach that is appropriate for the phase six students in the two labs.

2.4 Action Research

Cohen, Manion and Morrison (2000, p.227) drawing on the work of Elliot (1991) state: " *action research combines diagnosis with reflection, focussing on practical issues that have been identified by participants and which are somehow both problematic yet capable of being changed.*" This is just one of many definitions of action research but it mentions many of its elements. In terms of educational action research, it embodies the actions of teachers who want to improve their own practice. A particular problem is identified and it is reflected upon. Action then follows and this action is then reflected upon and the results of the action analysed. More action may be required to improve the problem still further or indeed, the original hypothesis may be radically changed in light of the initial results. The important point of action research is that it is carried out by the researcher on their own practice, either alone or in collaboration with others. McNiff (2002, p.15) describes it by saying: "*It is a practical way of looking at your practice in order to check whether it is as you feel it should be*". If you find that your practice needs improving then action can be taken and evidence produced to show how it has improved. Action research is not just for educational research; it can be applied to any context.

McKernan (1996) outlines the historical roots of action research. Kurt Lewin (1947a) is credited with defining the cycle of action research but he was not the first to use it. Action research started in the US in the early years of the 20th century. There were influences from several sources, such as the Science in Education movement of the late 19th and early 20th century, and the Progressive Education movement and the theories of John Dewey. The Group Dynamics movement in social psychology and human relations training led to the use of action research to understand and solve social problems during the 1940s. Lewin suggested action research as a form of inquiry into social problems. Lewin's model used cycles of action including planning, acting, observing, and reflecting (Lewin, 1946). Following this work, action research was then seen as an innovation in social inquiry. One of Lewin's main ideas was that practitioners from the real social world be involved in all phases of the inquiry.

In the 1950s, in the US, Stephen Corey was influential in leading a movement for curriculum reform by using action research. Practitioners would use their own research results to bring about improvements. Teachers and schools cooperated with outside researchers to undertake this research. McKernan (1996) then describes the decline of action research in the late 1950s which he suggests was due to the split between science and practice, and the establishment of expert educational research and development laboratories. Research became large scale and top down in practice, which discouraged small scale innovative practices. In the late 1960s, in the US, social unease was generated by the civil rights movement and the protests against the Korean and Vietnam wars. A new impetus then developed for action research in teacher education (McNiff, 2002). Attention turned again to small scale practitioner research as a form of educational and social change. In Britain, in the late sixties, the Schools Council was the national agency established to reform curriculum and examinations. At the same time as it was introducing changes to practical laboratory in schools, it established the Humanities Curriculum Project under the direction of Lawrence Stenhouse (Elliott, 1991). Stenhouse defined the aim of the humanities in education as: "*developing an understanding of social situations and human acts and the controversial value issues* *which they raise*" (Elliott, 1991, p.16). Stenhouse was of the view that there could be no curriculum development without the development of teachers' reflective capacities. He outlined a process model of curriculum development where he held the view that higher education researchers should support teachers. Research would still be initiated by full time researchers who would guide teachers, rather than teachers initiating their own research on their own practice. Stenhouse felt that students should develop their understanding of human actions and situations in the light of issues raised. This specifies a learning process rather than an outcome of learning. John Elliott, who worked with Stenhouse on the Humanities Project, went on to work with Clem Adelman on the Ford Teaching Project. This project undertook action research into implementing inquiry and discovery methods in twelve schools. It was based on teacher led research into their own practices and innovations, and the outside researchers took only a secondary role in the project. It helped bring awareness of teachers not only to their own practice but also the constraining effects their institutions had on their practice. Once this was highlighted they could then look at ways of bringing about change.

McKernan (1996) describes three types of action research. Type 1 is the scientific technical view of problem solving. This type follows a series of steps in an orderly process and Lewin's model (Lewin, 1947a) is an example of this. It is described as "*a series of spiralling decisions, taken on the basis of repeated cycles of analysis, reconnaissance, problem reconceptualization, planning, implementation of social action, and evaluation regarding the effectiveness of action*" (McKernan, 1996, p.17). The process starts with a general idea or problem and then fact finding is carried out and a plan devised. This plan is carried out and monitored to judge its effectiveness and this monitoring is used to show if the plan was successful or not. The researcher then spirals into another cycle of planning and implementation to achieve the desired effect. While these cycles are taking place the researcher is learning from the process. This type of action research is, in effect, a very scientific model and is usually carried out in collaboration with external researchers. At about the same time that Lewin was developing his model of action research, Hilda Taba, a curriculum theorist, working at the Massachusetts Institute of Technology, was also using action research on an exploratory project in intergroup education. The schools taking part in the project were asked to present problems that were worthy of tackling. Her model of action research followed the lines of Lewin's but differed in that nothing was rigidly fixed and that problem may change as the process develops.

Type 2 is the practical deliberative action research. The goal of this type is to understand practice and to solve immediate problems. It is also concerned with the process and not just the end product. "*As a theory of **practice**, action research attempts to make some difference to how people behave or live their lives: to how they feel and think*" (McKernan, 1996, p.21). The research takes account of moral issues. Elliott's model of action research follows the same basic steps as before but there is a strong link between practice and theory. The research is a self-reflective process in researchers examining their own theoretical world of practice, not that of an external researcher. The model has a series of action steps within a cycle. At the end of a cycle, the general idea is revised and another cycle started. Elliott (1991, p.70) states that:

- *"The general idea should be allowed to shift;*
- *Reconnaissance should involve analysis as well as fact finding and should constantly recur in the spiral of activities, rather than occur only at the beginning;*
- *Implementation of an action step is not always easy, and one should not proceed to evaluate the effects of an action until one has monitored the extent to which it has been implemented"*

A further development of this is the model of David Ebbutt (1983a). Instead of a series of spirals, he suggests a series of successive cycles, each providing feedback, both within and between the cycles of action.

Type 3 is critical emancipatory educational action research. It enables practitioners to seek out meanings and to organise action to overcome constraints. "*...it stresses equipping practitioners with discursive, analytical and conceptual skills so that they* *may be free of the control of positivism and interpretive theory through their communities of self-reflective group understanding"* (McKernan, 1996, p.25). A significant amount of work has been carried out on the critical emancipatory type of research in Australia at Deakin University. Much of this work has been reported by Stephen Kemmis. His model of action research consists of a series of reflective spirals in which a general plan, action, observation of action, and reflection on action takes place and then it moves to a new spiral. It is based very much on the original Lewin model. The main focus is on the problem itself and the generation of theories is an important aspect of this model. Teachers are seen as social reformers of education within the wider society and are bound up in the issues of control of education and political action that can be taken (McKernan, 1996). McKernan outlines his own time-process model (McKernan, 1996, p.28), which encompasses elements of all three types of action research. The three types of action research are developmental stages, according to Zuber-Skerritt (1992) and can be used to progressively develop from technical to emancipatory type but the ultimate aim should always be to improve practice in a systematic way.

Two essential aims of action research, according to Carr and Kemmis (1986), are to *improve* and to *involve*. The improvement should be in three areas, the first of which is to improve practice. The second is to improve the understanding of the practice. The third is to improve the situation in which the practice takes place. The action research should involve those who are part of the practice being considered.

Action research is about bringing changes to the subject of the research.

> ***Improvement*** *and* ***involvement*** *are central to action research. There is, first, the improvement of a* practice *of some kind; second, the improvement of the* **understanding** *of a practice by its practitioners; and third, the improvement of the* **situation** *in which the practice takes place.*
> (Robson, 2002, p.215)

From the three types of action research outlined, the model I have chosen to base this study on is that described by John Elliott. It falls into the type two action research, practical type, as described by McKernan (1996) and Carr and Kemmis (1986). The goal of this type of action research is to understand practice and to solve immediate problems. Elliott (1991, p.49) states the main aim of action research is: *"...to improve practice rather than generate knowledge. The production and utilization of knowledge is subordinate to, and conditioned by, this fundamental aim"*. He considers reflection about the relationship between processes and products, in particular circumstances, to be action research. This reflective practice constitutes an appropriate realisation of values in particular circumstances and these values depend on personal judgement. The very act of reflecting causes new understandings and realisation of values, so they are under constant review. For this study my own values and beliefs will undergo changes as it progresses and should lead to greater awareness of how the students regard the two labs. The reason for choosing this type of action research is that I have an immediate problem to solve, that of improving the effectiveness of the two labs and I will not be using an external researcher in the process. Since this is my first venture into action research I do not yet have the experience to regard this study as being emancipatory.

Using the methodology of action research on the phase six course could be problematic. One of the main themes of action research is to use the idea of a number of cycles and to adapt the plan after reflection has taken place at the end of each cycle. The course is only ten weeks in duration and a number of cycles need to be conducted to allow for changes that need to be made, after reflection, on the outcomes of the first cycle. Commenting on the number of cycles to make Elliott (1991, p.85) states: *"Again one cannot legislate for this, but I would normally feel it necessary to complete at least three, and perhaps four, cycles before one ought to be sufficiently satisfied with the improvements effected"*. In the time scale I have for the research this will be problematic but I can only judge the time for one cycle as the research progresses. It is clear that I will not be able to achieve the ideal number of cycles with one group of students. It should however, be possible to obtain an indication of what, if any, benefits the students gain from the study.

The validity of evidence in action research is as important as evidence in other types of research. Kemmis and McTaggart (2000) discuss the sacrifices that researchers make, in methodological and technical rigor for more immediate gains in face validity. They state that: "*It sacrifices methodological sophistication in order to generate timely evidence that can be used and further developed in a real-time process of transformation (of practices, practitioners, and practice settings)*" (Kemmis and McTaggart, 2000, p.591). The evidence produced by the research can be regarded as valid because the participants have to live with the consequences of the work and they are the ones with the inside knowledge to make judgements on the findings. Another way of checking the validity of evidence is to use triangulation. The idea of triangulation is a "... *method for bringing different kinds of evidence into some relationship with each other so that they can be compared and contrasted*" (Elliott, 1991, p.82). It involves collecting evidence from different angles or perspectives so that they can be compared and contrasted. In this study the sources of information will be from a control group, the research group and from my own perspective. By contrasting and comparing the views of the participants it should be possible to draw valid conclusions from the evidence.

2.5 Summary

This chapter has set out the main ideas and theories relevant to this study of the three areas of practical work, constructivism, and action research. Students expect practical work as part of courses but often find it lacking in relevance or interest. Teachers expect students to engage successfully with practical work but find students are confused and lacking in motivation. The expectations of neither are met. The literature on practical work points to clarifying realistic expectations and strengthening the links between theory and results. There is no one method of achieving this, so the subject and the context will be the deciding factors in designing strategies for achieving the expected outcomes. By using a constructivist approach, and allowing students to build on their own experiences and investigations, they can start the process of adapting the beliefs they hold at present about science topics. Instead of using a strict step-by-step approach to exercises, they can be allowed to investigate and discover new ideas or concepts. The teachers' role is to guide and encourage the students and provide support, but not to always provide them with the 'right' answers.

By examining the various types of action research and its aims, I have been able to identify one model that I believe is useful for guiding this study. I am also aware that this model is not a rigid design for action research but is useful for guiding the process, especially for myself, since I am inexperienced in carrying out action research. McNiff (2002, p.52) states: *"Practitioners need to see these models for what they are: guidelines for how we hope things will eventually fall out"*. What I hope will fall out of this study is that the students will engage more with the topics of the labs and develop openness to learning in a different context.

CHAPTER THREE

Theoretical Perspective and Methodology

3.1 Introduction

To make sense of this study it is important to have a clear understanding of my own beliefs of educational research and how it could be used to benefit my students and my professional practice. To achieve this, three main research paradigms will be explored: the Positivist Paradigm, the Interpretivist Paradigm, and the Critical Theory Approach. The characteristics and applications of the three paradigms are outlined in this chapter. Understanding the differences of the paradigms and how they are used, will lead to an understanding of why the critical theory paradigm was used for this study and how it fits in with my own beliefs. Once the theoretical perspective is clarified, it will justify the methodology and methods that were used to gather data for this study.

A research paradigm or perspective is: "*...the underlying set of beliefs about how the elements of the research area fit together and how we can enquire of it and make meanings of our discoveries*" (Wisker, 2001, p.123). My own beliefs will inevitably influence this study but, to arrive at valid conclusions, these beliefs will need to be grounded in the framework of the study.

3.2 The Positivist Paradigm

Cohen *et al* (2000, p.27) state that the positivist paradigm: "*...strives for objectivity, measurability, predictability, controllability, patterning, the construction of laws and rules of behaviour and the ascription of causality;...*".

The origins of positivism, according to Crotty (1998), are linked to Auguste Comte, a nineteenth century French philosopher who believed that it was only through observation and experimentation that real knowledge could be gained; reasoning alone was not sufficient. From the positivist point of view, only one reality exists and by applying a rigorous scientific approach this reality can be found.

The researcher for the positivist paradigm is generally outside of the research and does not take part in the research itself. He is external to the research and is deemed to be objective. The methods used are rigidly scientific and must be repeatable and not open to interpretation. The researcher is striving to find the real truth or reality and knowledge is gained through the senses. Observation and experimentation are needed to achieve this knowledge and the data generated is largely quantitative. Robson (2002, p.21) says: *"Essentially, positivists look for the existence of a constant relationship between events, or, in the language of experimentation, between two variables"*. By observing, we can see relationships between certain events. Theories can then be derived to suit the facts and these theories can then be applied to other situations. Laboratories exist to control the conditions for experimentation, so that variables are reduced and so leading to a more accurate result. The positivist approach can be very difficult to apply to human behaviour because of the variables involved. Even the objectivity of the observers is in doubt, as is commented on by Robson (2002, p. 21): *"However, it has been amply demonstrated that what observers "see" is not determined simply by the characteristics of the thing observed; the characteristics and perspectives of the observer also have an effect"*.

In terms of educational theory and research, positivists use research strategies that are based on the logic and methodology of the natural sciences. This should lead to knowledge that is not infected by subjective preferences and personal bias (Carr and Kemmis, 1986). From this, theories about education can be derived. By applying these theories to educational situations then it should be possible to predict the outcome of events. Taking this one step further, this prediction can lead to the control of educational process. Carr and Kemmis (1986, p.66) quoting from Travers (1969, p.16) state that educational research: *" in an activity directed towards the development of an organised body of scientific knowledge... which reveals laws of behaviour that can be used to make predictions and control events within educational situations".*

From the positivist point of view educational theory could guide practice because it could predict what would happen if modifications were made to educational situations. In this way, it could be used to control events so that desired goals are met. Positivism also ignores the intensions, individualism, and freedom of humans. It suffers many of the same problems as behaviourism (Cohen *et al,* 2000), namely our inability to infer causes from behaviour and to identify the stimulus that brings about the response. Because the scientific experiments are so restrictive the outcomes are unlikely to reflect real world situations. In the positivist paradigm knowledge is transmitted to the learner and the learner should then store this knowledge. Little thought is given to the processes involved in determining how the learners actually acquire this knowledge (Gallagher, 1993).

This study depends on feelings and intuition as it progresses. It is impossible for me, as the researcher, to be totally objective. I will be recording my thoughts and feelings as they occur in the labs. I will not be external to the research or a mere observer; I will be part of the activities in the labs. I will not be rigidly controlling the actions of the students and the outcome of what will occur is not predictable. Whatever occurs will be as a result of what I have attempted to implement and the reaction of the students to it. I have ideas about what I hope will be the expected outcome but these outcomes are by no means certain. By reflecting on the events that occur, I will be making judgments and acting on them. These are not the tools used for the positivist paradigm. Events will not be looked at objectively and there will be little predictability. Every action in the lab will not be strictly controlled and indeed, it is the lack of control that I believe will be the most problematic aspect of this study. The students will be allowed to make their own decisions about which exercises to choose for their investigations. It is for these reasons the positivist approach is rejected as a suitable paradigm for the study I am undertaking.

3.3 Interpretivist Paradigm

Interpretive researchers try to understand the world of human experience. They focus very much on the individual and his actions. These actions are then interpreted by the observer and, as such, it is the view of the researcher that is deemed important. Cohen *et al* (2000, p.23) state: "*Actions are only meaningful to us in so far as we are able to ascertain the intentions of actors to share their experiences*". The origins of the interpretivist approach can be traced back to the technical method of interpreting meanings from the Bible, called hermeneutics. It was developed by seventeenth century Protestant theologians, who wanted to show the meaning of the Bible, by a direct reading of the text. Later, in the eighteenth century, hermeneutics was used to interpret literature and later still, in the nineteenth century, the idea of hermeneutic interpretation was elaborated by German social theorists. The interpretivist approach has since spread to the English speaking world, mainly due to the criticisms of the positivist approach, especially in the 1960s and 1970s (Carr and Kemmis, 1986).

Interpretive researchers can form theories for the way individuals react in given times and places and compare their actions in different times and places. The theories follow the research and there is not just one reality. The theories have meanings for particular people at particular times and in a particular context, so there can be as many theories as there are people and contexts that occur. The researchers do not form part of the action or try to change the actions of the participants. They are observers who try to understand the people and the situations and derive theories from the observations, and these theories may then be transferable to other situations. Since the researcher is external to the research, he speaks on behalf of other people and can regard people as objects of study. The theories generated are about external situations (McNiff, 2002).

The interpretive approach is not a suitable paradigm for the study I will be carrying out because I will be involved in making changes to the delivery of the lab classes and assessing how these changes affect a particular group of students. I will not be just a simple observer. I will be part of the action that is taking place and trying to implement change. These changes will affect myself as well as the participants in the research and they may not follow the predicted path. This act of interfering in the research is not part of the interpretivist paradigm.

3.4 Critical Theory

The type of research I will be conducting is more in accordance with the third paradigm, critical theory. It is used to give a view of society and behaviour and to allow changes to take place and address inequalities. Cohen *et al* (2000, p.28) state that: "*Its purpose is not merely to understand situations and phenomena but to change them. In particular it seeks to emancipate the disempowered, to redress inequality and to promote individual freedoms within a democratic society*".

The early work on critical theory in the 1930s was influenced by Habermas and the so-called Frankfurt School, which included such people as Horkheimer, Adorno and Marcuse. They saw the methodologies then in use as being unsuitable for enquiries in social science because they did not recognise the historical, cultural, and social situatedness of researchers. Critical theory developed as an approach to offer an oppositional response to dominating influences and emancipatory hope (McNiff, 2002). Habermas named three interests as technical, practical, and emancipatory. The technical interest characterises the positivist approach. The practical interest characterises the interpretivist approach and the emancipatory interest characterises the critical theory approach Critical theory is concerned with action that is informed by reflection with the aim to emancipate (Kincheloe, 1991 in Cohen *et al*, 2000). Habermas also realised that social conditions could distort self-reflection and self-understanding, so self-emancipation could only be realised by a critical social science that could recognise these conditions and eliminate them. Carr and Kemmis (1986, p.136) go on to say:

> *Hence, a critical social science will seek to offer individuals an awareness of how their aims and purposes may have become distorted or oppressed and to specify how these can be eradicated so that the rational pursuit of their goals can be undertaken.*

Critical theory has its own methodologies, ideology critique and action research (McKernan, 1996). Habermas believed that ideology was the means by which powerful groups promote and legitimate their interests at the expense of disempowered groups. Ideology critique has the task of uncovering the vested interests at work and to show participants how they may be acting to keep a system in place that empowers some and disempowers others (Robson, 2002). The purpose of this study is not to show the power relationship between apprentices and the department of Electrical Services Engineering or FÁS and attempt to change them. There may well be issues involved here but, it is not the focus of this study. It is the area of action research that is important for this study. McKernan (1996) discusses three types of action research: scientific action research; practical deliberative action research; and critical emancipatory action research. It is practical deliberative action research that I will be using for this study because its goal is "*understanding practice and solving immediate problems*" (McKernan, 1996, p.20). It is the process and not just the outcome that is important. I will be following the models of action research as proposed by Elliott (1991). The cycle usually follows the format of identifying a general idea, reconnaissance, general planning, developing the first action step, implementing the first action step, evaluation, revising the general plan and then developing the second action step and continuing in a spiral.

My own beliefs in education and teaching are a critical part of this study. Since I will be attempting to use a constructivist approach, my own beliefs will have a large impact on how I conduct this study. The theoretical perspective is a way of looking at the world and making sense of it (Crotty, 1998). The theoretical perspective I believe in is critical theory. Crotty (1998, p.159) concludes: "*…critical inquiry remains a form of praxis - a search for knowledge, to be sure, but always emancipatory knowledge, knowledge in the context of action and the search for freedom*". Over the years, my teaching has changed from being simply the provider of information for examinations, to the provider of opportunities for learning. My own beliefs have shifted from the idea that there is a set amount of knowledge to be imparted to students, to the concept that learning is about constructing knowledge in the context of a particular situation. I no longer believe that I can give students knowledge. If that were possible, then every student would pass all assessments without any problems; in reality this does not happen. Bettencourt (1993, p.40) says this clearly when he states: " *We all have had the experience of seeing that what our students made of our teaching bore little resemblance to what we had intended them to learn*". I am very aware that students can learn something completely different from what I intended. I gave them all the same information but this was translated into different versions of what I intended. I can now understand that the students are constructing their own understandings from the information I give them. How this knowledge is constructed depends on the students' own beliefs, experiences and the social context in which the students find themselves (Tobin, 1993). I now believe that constructivism is a very valid epistemology. While students will all construct knowledge in different ways, it is not true to say that all personal constructs are viable. It is the teacher's job to ensure that students do not retain naïve or incorrect knowledge, in the context of the classroom. Tobin (1993, p.5) reinforces this by saying:

> *Accordingly, if a teacher regards the constructions of any individual to be inviable in the larger set of contexts in which actions are to occur, it is the teacher's duty as a professional to structure learning environments to facilitate the process of learning of what society regards as having greatest viability at that particular time.*

At this particular time, what society regards as having greatest viability for the phase six electrical apprentices is what is contained in the syllabus as set out by FÁS (2000). I therefore see it as my duty as an educator to structure the learning environment to facilitate this process of learning. The constructivist approach that will be adopted involves allowing the students to build up their knowledge, to make discoveries, to use primary sources of information, to see the 'big idea', to question, and to work in groups (Brooks and Brooks, 1993). By presenting the students with problems that they could encounter in work situations, I want them to discuss viable solutions. The students will have access to their own notes, text books, regulations for electrical installations, and to exercise sheets for set exercises in the labs. By using the knowledge they already have about the topics, they can use the sources of information available to them to build on this knowledge and construct theories about the problems. Once they have developed theories about the problems and identified possible solutions, they can test the solution by using the exercises available in the lab. By working in groups the students will be able to exchange ideas and see different perspectives. It is hoped that by allowing the students to investigate the problems that they will engage with the topics in the labs in a meaningful way.

3.5 Methodology

In chapter two of this study, I looked in detail at the three different types of action research; the scientific; practical; and emancipatory. Having considered the characteristics of each, I chose the practical type as described by McKernan (1996) and Carr and Kemmis (1986) because of its goal of solving immediate problems. I also chose the action research model as described by Elliott (1991) because of its flexibility in allowing changes in the original plan, which can reflect issues that arise during the cycles of research, rather than adhering rigidly to the original ideas. Reflection is a key aspect of the action cycles and Cohen *et al* (2000) describe one of the key principles as being *reflexive critique*; the process of becoming aware of our own perceptual biases. By being aware of these biases, they can be taken into account during the reflection stage of the process and issues can be dealt with in an open and ethical manner.

3.6 Summary

It has been shown in this chapter that I have considered three main theoretical perspectives, positivist, interpretive, and critical inquiry. I have chosen the critical inquiry paradigm and one of its methodologies, action research, as the framework for this study. I believe that the epistemology of constructivism links closely to critical inquiry because it allows the construction of knowledge in a particular context. As experience grows, these constructs will change and allow a new interpretation of what we experience. This can lead to new understandings and concepts and allow us to see ourselves in our social context. With this new knowledge, we are in a position to reflect critically and to determine what direction our learning should take.

In the context of the electrical apprentices in phase six, it is important for me to be able to produce an environment in which the students can control their own learning. It is not for me to simply transmit information to them but, to allow them the opportunities to build on their previous experiences in phase four and their work places. Mullins (2005, p.169) commenting on lecturers for apprentices says: "*A lecturer will be an expert in their craft specialisation but in this context he/she must also be an expert in the teaching of the craft*". To become that expert I need to understand how the students learn and what I need to change to help that learning to take place. By carrying out this study, I hope to improve this learning environment and facilitate the construction of viable knowledge by my students so that they will become aware of their own potential and act on it for their own benefit.

CHAPTER FOUR

Presentation of findings

4.1 Introduction

This chapter outlines the design of the research and the different methods of data collection. It then presents the analysis of the data collected during the course of this study. It is used to give: *"...a clear , annotated record of what has been discovered"* Wisker (2001, p.237). The type of data collected is both quantitative and qualitative in nature. Action research was the methodology used for the study and, in effect, two cycles were used. The first was five weeks in duration and the second lasted four weeks. The *research group* consisted of sixteen male phase six electrical apprentices. Due to timetabling restrictions, the same group of sixteen apprentices was used as the research group for both the electronics and measurements labs. The responses of the research group to the questionnaire were compared to the responses from all other groups of apprentices, to the same questionnaire, referred to in this study as the *control group*. The control group were the intake of apprentices on the previous block release course, to that of the research group, so that the questionnaire data could be used to guide the changes in the constructivist approach with the research group.

4.2 Research Design

The focus of the study was to see if using a constructivist approach to lab delivery would lead to an improvement in lab work for the phase six electrical apprentices. The reasons for choosing action research as the methodology have already been described in chapter three. To guide the research design process Cohen *et al* (2000) suggest many questions about the research that need to be answered. The main questions I needed to answer were: what methods needed to be used to gather data; who would participate in the study; how would the data be analysed; how would the validity be addressed. Because I was using action research it would involve interaction between myself and the students in the classroom. This immediately brought up the question of ethics and permissions. An ethics statement was drawn up and the necessary permission from the head of department and the students themselves obtained, before any data collection began.

Before any changes could be introduced in the labs the current situation had to be established and a questionnaire was used to do this. The data from this was then used to formulate a plan to introduce problems into the labs that the students could tackle. The changes being considered involved posing the students problems to do with the particular topic of the labs. The problems would be as close as possible to ones that the students could encounter as part of their work situations. The particular types of problems posed should make predictions testable by the students, be complex enough to have multiple problem solving approaches, benefit from group work, and use relatively inexpensive equipment (Brooks and Brooks, 1993, p. 36). The students would be allowed to select exercises to carry out, to prove particular concepts in relation to the set problems, once they have developed what they consider to be viable solutions. These exercises would always remain within the constraints of the syllabus as set out by FÁS in the standards based apprenticeship (FÁS, 2000). A sample of one of the problems used in this study is provided in Appendix E. It is clear that there would be a limited number of options available to the students when choosing exercises. These constraints include the restricted amount of equipment available, the exercises detailed in the syllabus, and the limited time for each lab session. The other methods of data collection chosen were interviews, lab feedback sheets, examination results and a reflective journal. These are all described in detail in the next section. The data would then be analysed and presented and conclusions and recommendations made. The validity of the qualitative data can be a difficult issue but in this study I understand validity as being able to show that the conclusions are justified from the data collected and that the methods used were appropriate.

4.3 Methods

The methods used in this were: a questionnaire to all phase six apprentices; lab feedback sheets; a focus group discussion with four students from the research group; individual interviews with four students from the research group; reflective research journal; and examination results.

Questionnaire

As part of the action research cycle, the first step was to assess the present situation. Lewin (1946) listed four processes in action research: planning, acting, observing and reflecting. Before taking any action, I needed to plan what type of changes to make to the delivery of the labs. To understand how the students perceived the labs currently, it was necessary to obtain their views. With a potential pool of approximately 150 students, it was quite clear that a simple format for the collection of this data would have to be used. A method was needed that could be analysed simply, yet provide the necessary data. Following a review of different research methods (Robson, 2002; Cohen *et al*, 2000), a decision was taken that a questionnaire would achieve this aim. Since the questionnaire would have to be carried out during normal class time, it had to be relatively short and undemanding of the students. The apprentices only attend the college for a period of ten weeks for the phase six course and there is a tendency for them not to see themselves as part of the student population and as a result, are not overly concerned by what occurs in the college. The idea of being part of educational research is not one that would come naturally to them. The simpler the questionnaire, then the greater the probability of it being completed fully and returned.

The exact nature of the questionnaire was then examined. Foddy (1993) describes in detail the methods that can be used for measuring attitude of respondents to particular topics. The list includes two common methods: simple open-ended questions and simple rating scales. It was decided to use the simple rating scale, for the majority of the questions, because of the ease with which respondents could fill in boxes. Commenting on the popular use of rating scales Foddy (1993, p.155) states: "*A possible* *explanation lies in the facts that they appear to be easy to prepare and that respondents seem to find them easy to use*". On the Likert scale, only one box from a choice needs to be ticked, which makes filling out the questionnaire quick and easy. The drawbacks to this type of scale are that there is a lack of consensus about the way attitudes should be defined. Strongly agreeing with one topic may not carry the same intensity as strongly agreeing with another topic, so care needs to be exercised. The number of categories for the answer is also limited. Foddy (1993, p.166) discusses the effects of the number of categories on the validity of responses. It is suggested that seven categories should be used but he adds that: "*This conclusion should not obscure the importance of both properly defining the topic(s) to be rated and properly defining the categories that are to be used to make the ratings*". Bearing all this in mind, I decided on five categories for the responses and all the categories were clearly labelled. By completing the questionnaire during normal class time, it was hoped that the completion rate would be higher than if the questionnaires were given out and returned later. The open-ended questions were included to enable the students to add any comments or opinions that the Likert scale questions did not cater for. It was hoped to: "*...catch the authenticity, richness, depth of response, honesty and candour which...are the hallmarks of qualitative data*" (Cohen *et al*, 2000, p.255). The questionnaire consisted of four general questions dealing with education, age, phase four centre attended, and type of work normally carried out. These were then followed by twelve Likert scale questions relating to activities in the electronics and measurements labs. There were then two open-ended questions dealing with likes and dislikes in the labs. A further two open-ended questions asked for suggestions on ways of improving the labs and for any final general comments. The questionnaire was trialled with one group of apprentices and following feedback from them, a number of minor changes were made to the wording of some questions. A copy of the questionnaire is provided in Appendix A.

Lab Feedback Sheets

The lab feedback sheets were used to allow the students to express their opinion on what was occurring in the electronics and measurements labs each week. It consisted of five Likert scale questions and two open ended questions. A copy is provided in Appendix D. The Likert scale was chosen because a lab feedback sheet was used at the end of each lab session and, like the questionnaire, had to be kept simple and be designed to be reasonably quick to fill in. The questions dealt with understanding the aims of the lab sessions and the students' level of confidence and confusion about the lab topics. The last two questions allowed the students to express any dislikes about the labs and any other comments they wished to make.

Focus group

The focus group discussions were not part of the original design of the research. After experiencing problems with progress with the research group it was decided to use week five as an opportunity to record the depth of feeling of the students to the investigation type method. The focus group was recorded on the 10th Feb 2005, in the electronics lab itself. The discussions were on the students feelings towards the investigation type approach and the relevance of topics. The recording was then transcribed and a copy is provided in Appendix K. The qualitative data from the transcripts was analysed to establish main themes and to check for links to these themes. The main themes were then used to reflect on the outcome of the first cycle of the action research and the themes from the focus group were then used to assist in the planning of the next action research cycle.

Individual Interviews

The type of interview was decided on after consulting the literature (Cohen et al, 2000; Kvale, 1996; Foddy, 1998) about the different types of interview. The semi-structured interview was chosen because it allowed standard questions to be asked of each student but also offered the flexibility to follow up on issues that might arise during the interviews. The purpose of the interviews was to get personal views of the students in the research group, about particular aspects of the labs. The individual interviews were recorded with four students, on the 10th March 2005. A small room away from the labs was used and the interviews were relatively short at approximately six minutes each. A copy of the interview questions is provided in Appendix H. A full transcript of the interviews is provided in Appendix I.

Reflective Research Journal

The reflective research journal was chosen so that I could keep track of events as they occurred and also to record the feeling at the time, so that it is more than just a simple log of events. It can be used to show the development of the action and also the development of the thinking (McNiff, 2002) as the study progresses. This was important as the entries in the journal show the problems developing in cycle one and the change to the discussion type approach in cycle two. Extracts of the diary are used in the presentation of the findings for cycles one and two.

Examination Results

The examination results were used to compare the performance of the research group against their peers, not the control group, in the same examinations. As the labs are not formally assessed, it is difficult to obtain definitive evidence of their performance in practical work carried out in the labs. A number of the examination questions on the electrical science and craft theory papers cover the topics of the experiments in the labs and, the results of these particular questions can be compared for the two groups. Since all these topics are also covered as part of the theory elements of the course there is no way of determining if the learning took place in the labs or the classroom. Despite this drawback, the exam results were included so that the performance of the research group could be compared to their peers to ascertain if they were a 'typical' phase six group.

By using the different methods, it was hoped to gain an overall view of what occurred in the labs by looking at the research group's view, my own view of what occurred and, to some extent, their performance in the examinations.

4.4 Findings of the Questionnaire

The questionnaire was distributed to 144 phase six electrical apprentices. A total of 107 replies were returned, representing a 74% return rate. On the days the questionnaire was distributed, some students were absent from classes and others chose not to participate in the research.

All the questionnaire data was entered into Microsoft Excel and charts were drawn based upon this data. The raw data from the questionnaire was entered into a spreadsheet and the data assigned codes, and the number of occurrences of each code was then used as a percentage of the number of responses to the particular question on the questionnaire. The data for all twenty questions are presented in this section in a series of charts which compare the results of the control group to the results of the research group. The Likert scale questions show the results for the electronics and measurements labs on the same chart so that the data can be compared easily. The qualitative data from questions seventeen to twenty is shown as a series of charts with the main themes.

Data Analysis

The qualitative data derived from questions 17 to 20 was analysed to provide main themes. Robson (2002 p.459) lists a set of analytical steps from Miles and Huberman (1994) that can be used to analyse the data. These include steps such as:

- Giving codes to the initial set of materials
- Adding comments, reflections etc.

- Identifying similar phrases, patterns, themes, relationships, sequences, and differences
- Elaborating a small set of generalisations that cover the consistencies
- Linking these generalisations to a formalised body of knowledge

Dey (1993) describes how the qualitative data can be subdivided and assigned categories and then how decisions can be made about how the categories can be situated into context of the analysis. All the phrases used for the open ended questions were written out and then examined for common wording or phrases. This reduced the number of categories significantly. These categories were then examined for common themes and the number of categories reduced again. A sample of the data is provided in Appendix J, which shows the responses for question 17 on the questionnaire.

Question 1

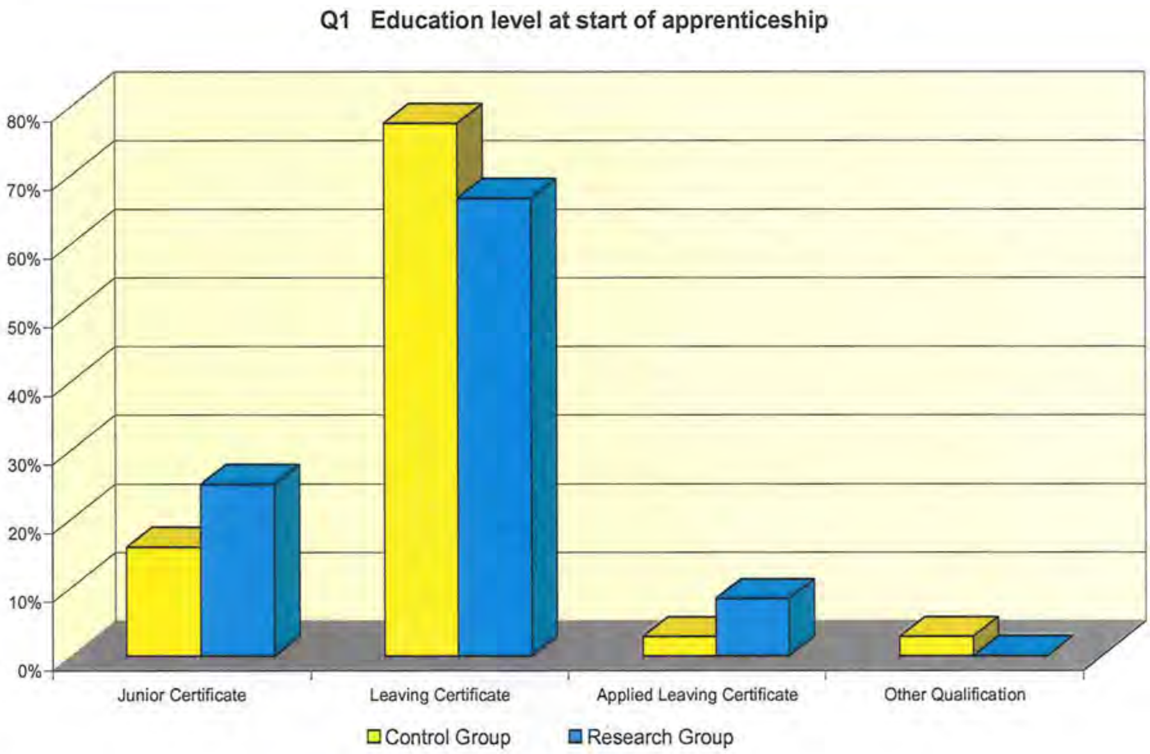

Figure 4.1 Question 1

The first question about the highest educational qualification achieved at the start of apprenticeship had four options: Junior certificate, Leaving Certificate, Applied Leaving Certificate, and Other qualification. Figure 4.1 shows the results of question 1 on the questionnaire. The results show that 78% of the control group had achieved the Leaving Certificate at the start of the apprenticeship. For the research group this figure was 67%. The other qualifications that students listed on the questionnaire included a BSc in Applied Science, a diploma in Information Technology, and a certificate in Horticulture.

Question 2

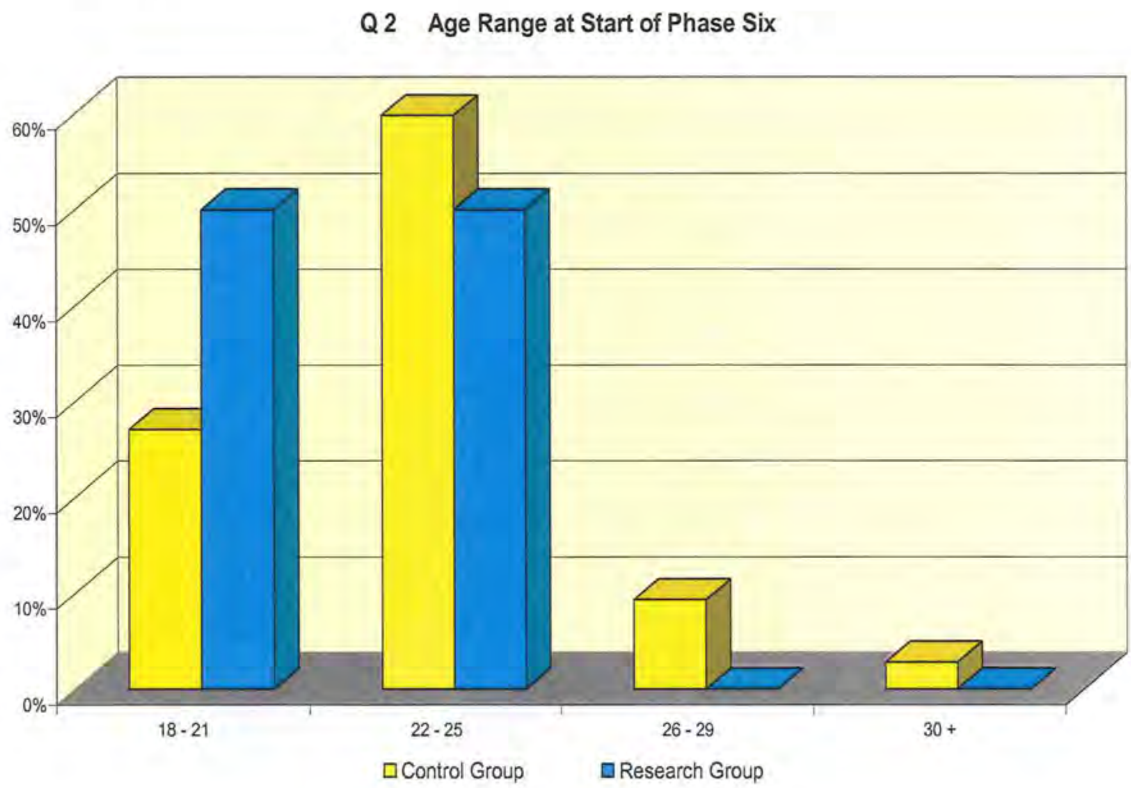

Figure 4.2 Question 2

Question 2 asked the age, in years, of the students at the start of the phase six course. The results are shown in Figure 4.2. For the control group 60% were in the 22 to 25 years range and 27% in the 18 to 21 years range. For the research group 50% were in the 22 to 25 years range and 50 % were in the 18 to 21 years range. The minimum age at the start of the apprenticeship is 16 years but there is no upper age limit (FÁS, 2004). The standards based Apprenticeship is based on achieving the required standard in each of the seven phases and has no restriction on the length of time for completion of the apprenticeship but, in practice, it is approximately four years.

Question 3

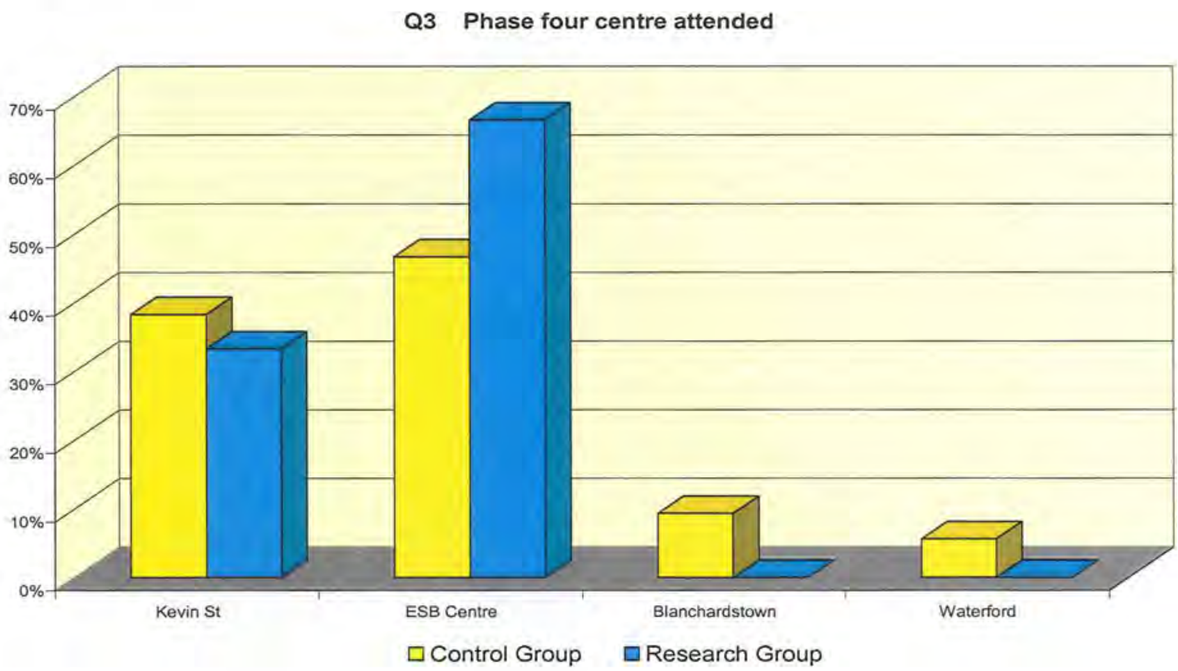

Figure 4.3 Question 3

Question 3 on the questionnaire asked which centre had been attended for phase four. The results are shown in Figure 4.3. For the control group 38% attended Kevin St. and 47% attended an Electricity Supply Board (ESB) centre. For the research group 33% attended Kevin St. and 67% attended an ESB centre. In the control group, there were also a small number of students who had attended either Blanchardstown Institute of Technology or Waterford Institute of Technology. It is significant that only a third of the research group attended Kevin St. for phase four. For the majority of students it was the first time that they were exposed to the teaching methods of the department.

Question 4

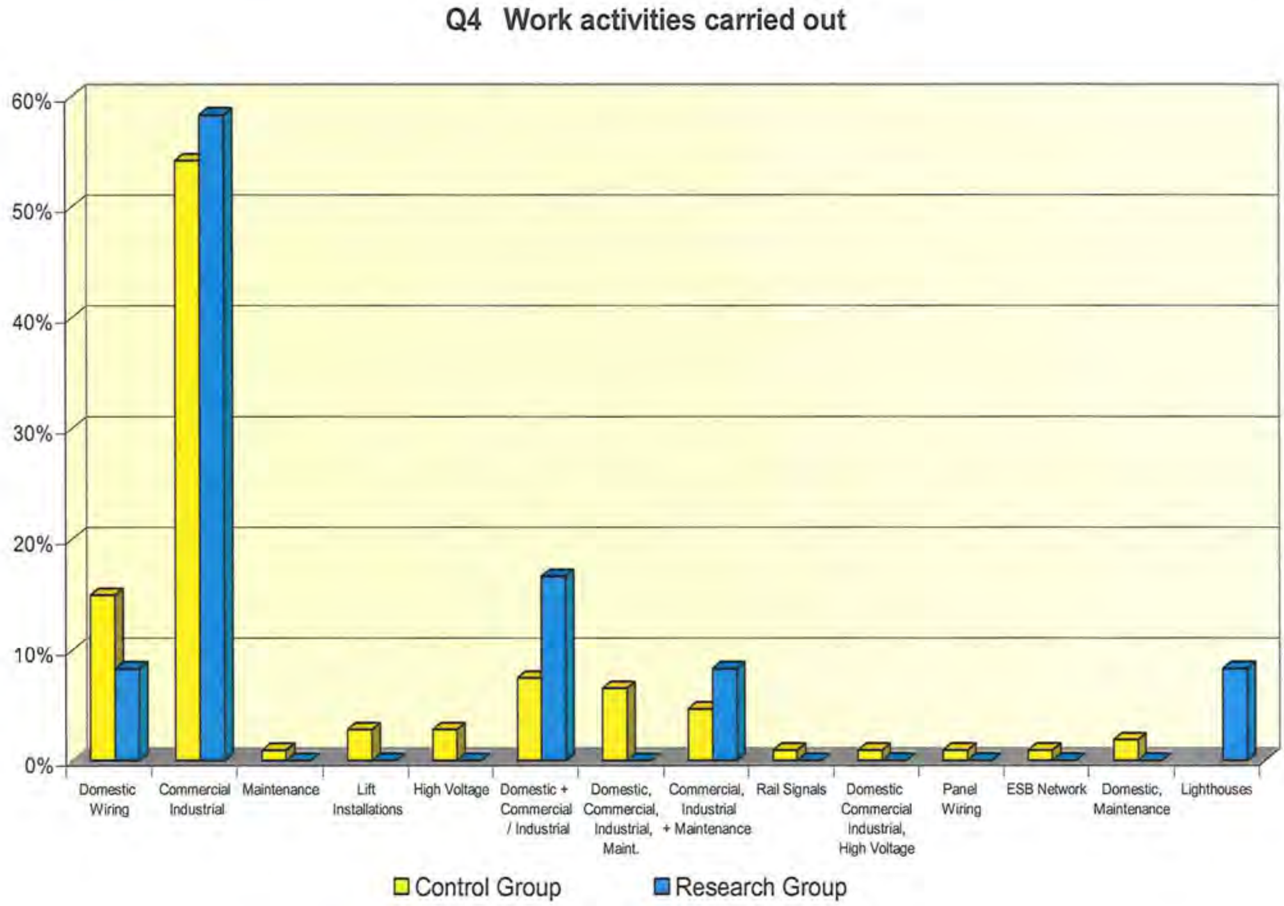

Figure 4.4 Question 4

Question Four asked for type of work activity normally carried out by the apprentice. The results are shown in Figure 4.4. The results show that for the control group 54% of the apprentices carry out commercial/ industrial type wiring. Domestic wiring only accounts for 15% of the apprentices. The other categories are mainly combinations of the wiring types and more specialised activities such as lift installations (3%), rail signalling (1%), ESB networks (1%) and high voltage work (3%). For the research group 58% carry out commercial/industrial, 8% work on domestic wiring only, and 17% carry out a combination of both. Of the remaining classifications, 8% work on a combination of commercial/industrial and maintenance work, and 8% on lighthouse work.

Likert Scale Questions

The next twelve questions used a Likert type scale to allow the students to express their feelings on various aspects of the electronics and measurements labs. The results of these are shown in Figures 4.5 to 4.16. There were five categories to choose from. These were: *Strongly Agree, Agree, No Opinion, Disagree, and Strongly Disagree.*

The Likert scale questions had a high completion rate. As can be seen from table 4.1, seventeen questions had a completion rate of 99%, six questions had a completion rate of 98%, and one had a completion rate of 100%.

The results for the electronics lab are shown on the left hand side of the bar chart and the results for the measurements lab are shown on the right hand side. The results of the first survey, to the control group of apprentices, are shown as the *control group* and the results of the students who participated in the research are shown as the *research group*. The results of both groups can be compared directly on the bar charts. The question is shown at the top of the chart.

Question 5

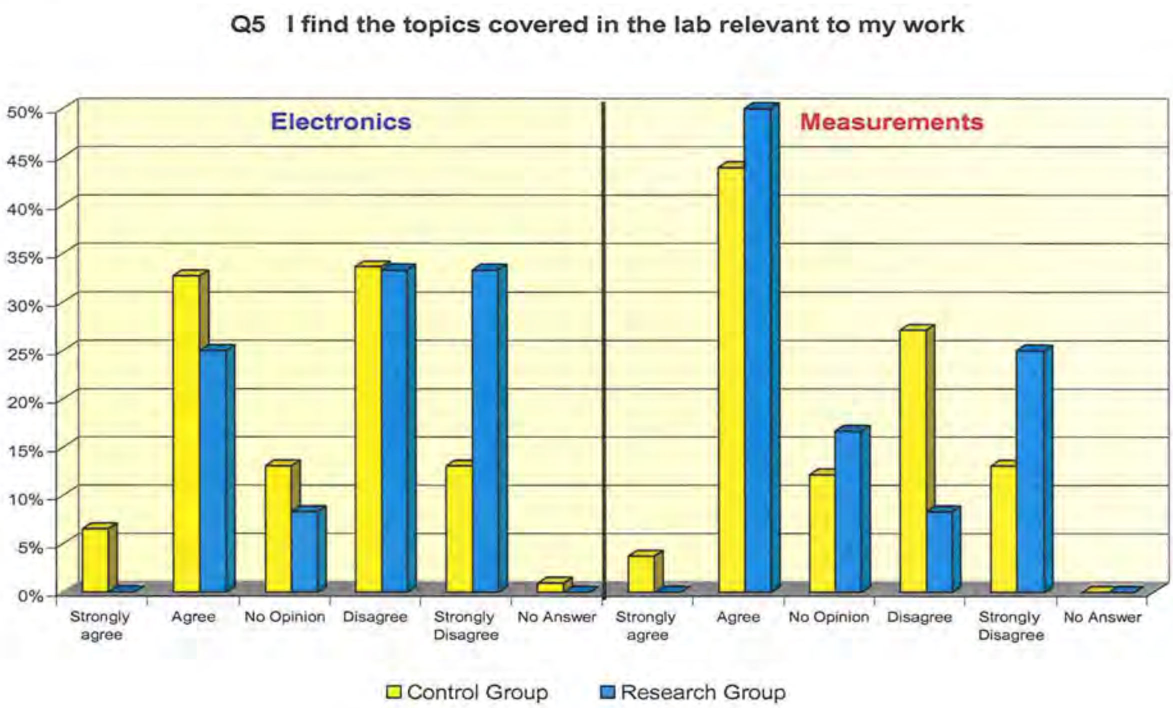

Figure 4.5 Question 5

Figure 4.5 shows the results for question 5 of the survey. About one third of students from the control group believe that the topics covered in the electronics lab are relevant to their normal work activities. For the research group, 33% *strongly disagree* with the relevance of the topics compared to only 13% for the control group. There is a significant difference in opinion between the control group and the research group. For the measurements, there is also a difference in opinion to the relevance of the measurements topics but not quite as strongly as in the case of the electronics. In general both groups found the topics in the measurements more relevant to work situations than the topics in the electronics.

Question 6

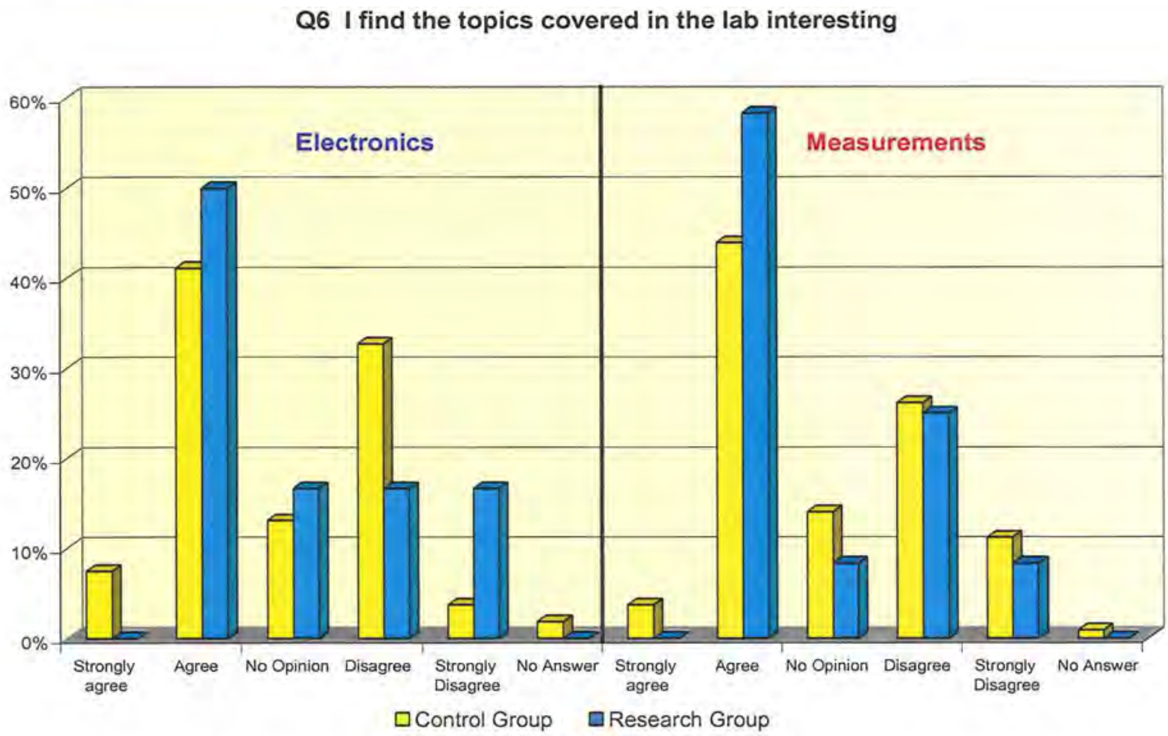

Figure 4.6 Question 6

Figure 4.6 shows the comparison of results for question 6, the interest levels in the electronics and measurements. For the control group in the electronics, 41% *agree* that the topics are interesting but 33% *disagree.* The research group show a higher figure, 50%, agreeing and 15% disagreeing. The research group also has 15% who *strongly disagree*. For the measurements, 44% *agree* from the control group and 58% for the research group. The strongly disagreeing figures are lower for both groups when compared to the electronics. Overall the groups found the measurements lab topics more interesting than the electronics.

Question 7

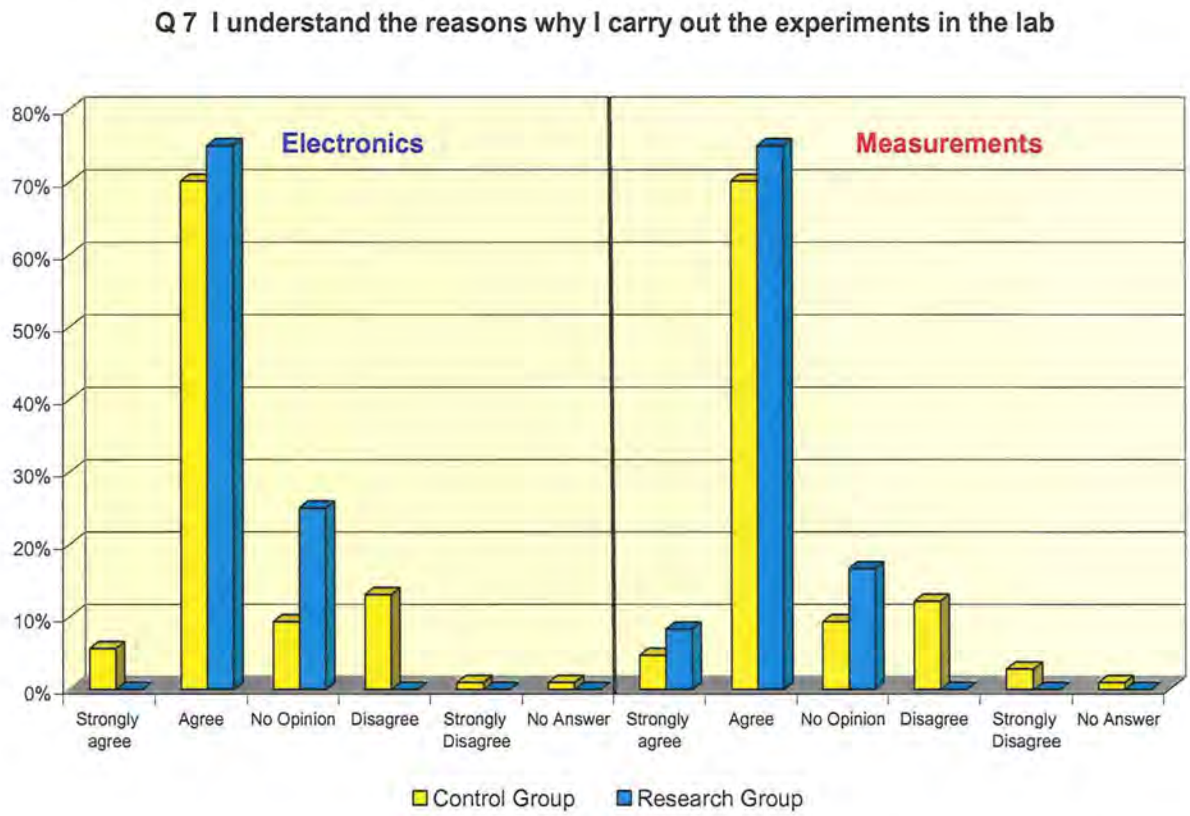

Figure 4.7 Question 7

The results of question seven are shown in Figure 4.7. Both groups show a high level of agreement for understanding the reasons for carrying out the experiments, both for the electronics and the measurements. There are very few strong opinions against understanding the reasons, for either the electronics or measurements. These figures are significant because understanding the reasons for lab work is fundamental to linking the practice and theory of the topics as is discussed in chapter five. These results also have a significant link to question eight, dealing with the principles of the experiments.

Question 8

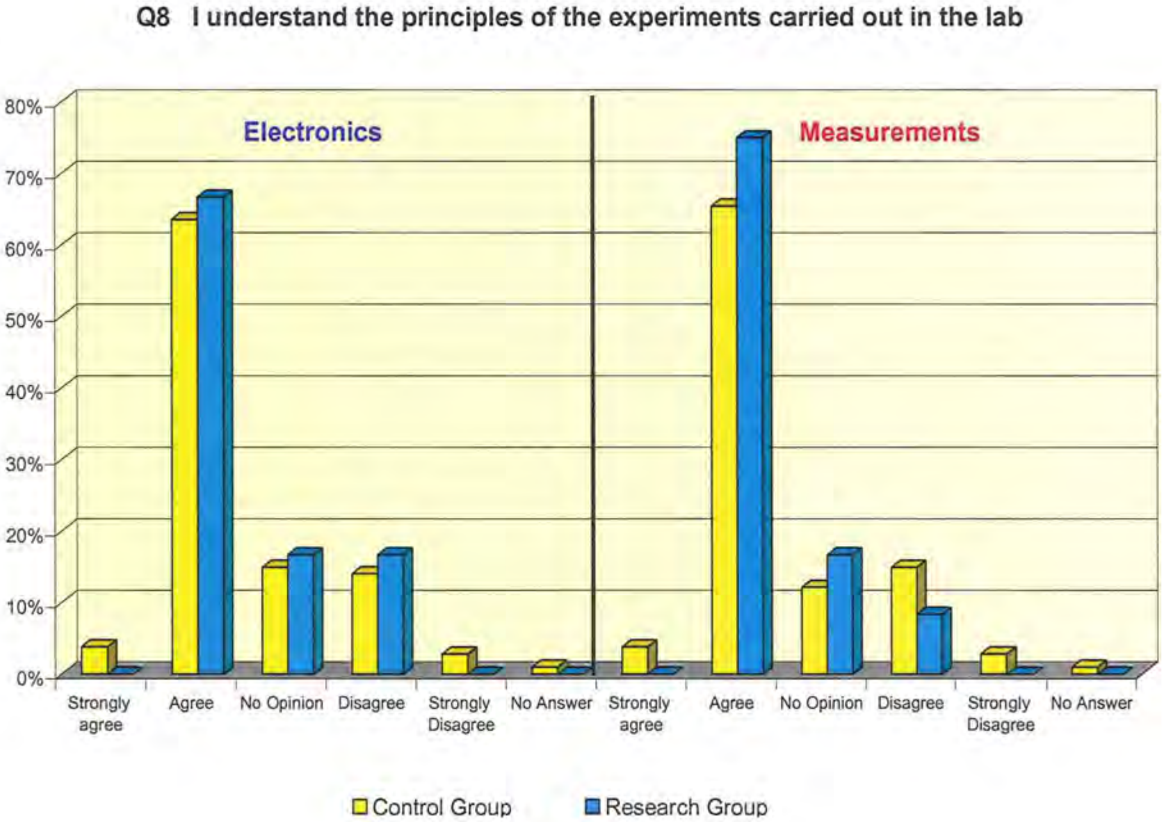

Figure 4.8 Question 8

Figure 4.8 shows the results of question eight in the survey. For electronics, approximately two thirds from both the control group and the research group claim to understand the principles of the experiments carried out in the electronics lab. There is little variation in the figures. For the measurements, approximately 10% more from the research groups say they *agree* that they understand the principles. There are very few *strongly disagree* opinions. Understanding the principles of the experiments is again one of the main aims of carrying out the lab work.

Question 9

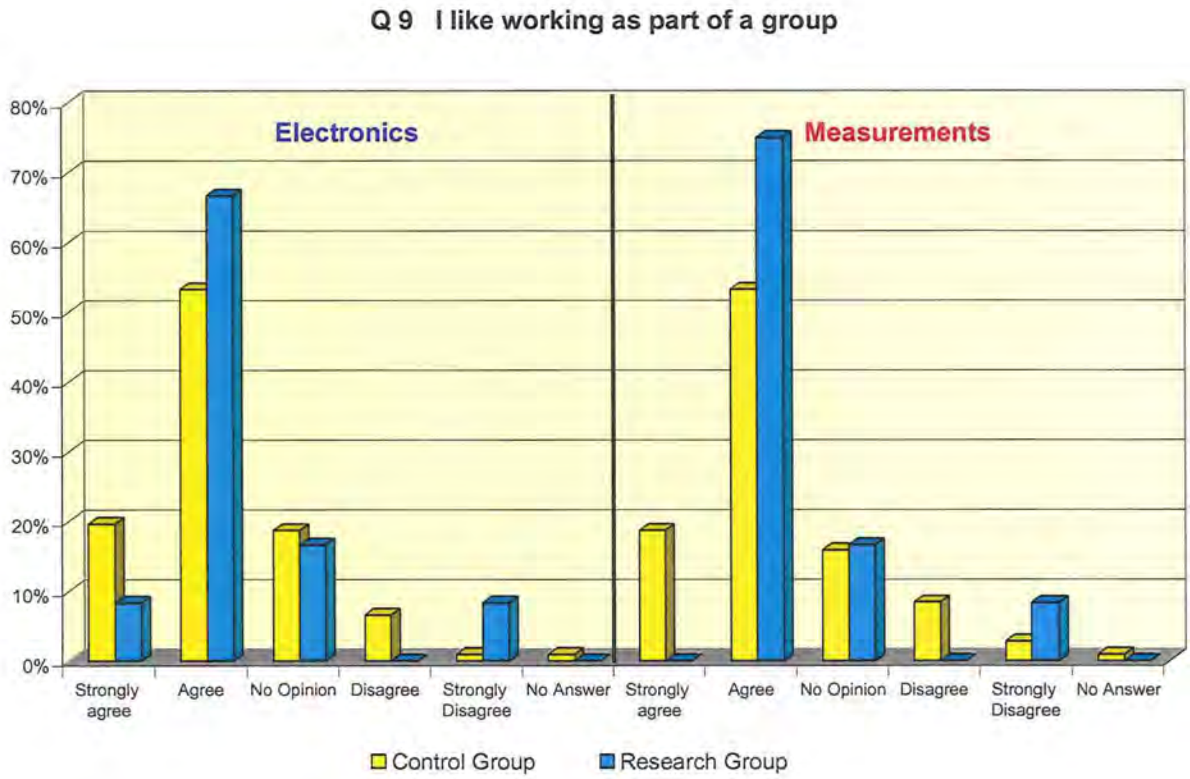

Figure 4.9 Question 9

The results for question nine on the questionnaire are shown in Figure 4.9. For working as part of a group, the research group shows a higher level of *agree*, 76%, than the control group, 53%, for the electronics lab. However, the control group shows a higher figure for *strongly agree*, 18%, compared to 8% for the research group. The research group has a higher *strongly disagree* figure than the control group. For the measurements, this trend was repeated. Overall, the research group tended to like working as part of a group, more so for measurements than electronics. This question achieved one of the highest figures for agreeing with a statement on the questionnaire.

Question 10

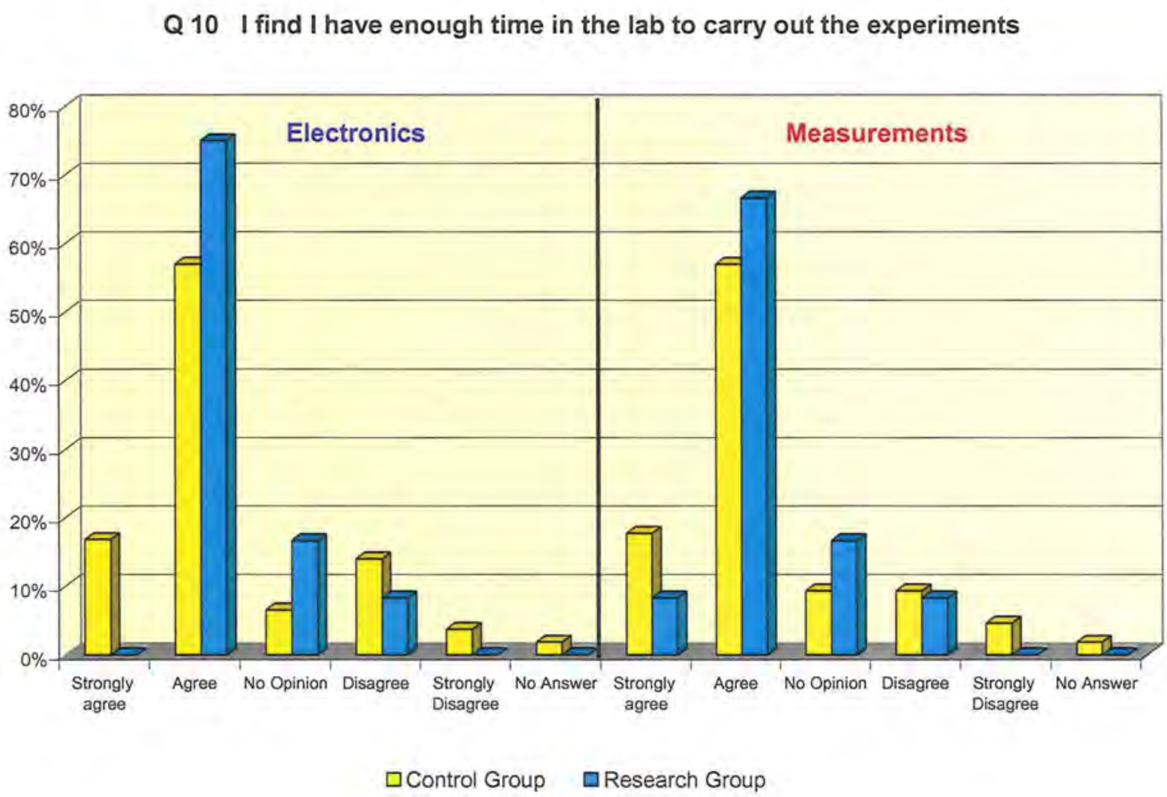

Figure 4.10 Question 10

The results for question 10 are shown in Figure 4.10. For having sufficient time in the electronics lab, 75% of the research group *agree*. For the control group the figure is lower at 57%. The *strongly agree* figure is 17% for the control group but none of the research group *strongly agree*. For the measurements lab the control group's figures are very similar to the electronics lab but the research group has a lower *agree* figure but a higher *strongly agree* figure. Lack of time in the labs does not appear to have been an issue for most students.

Question 11

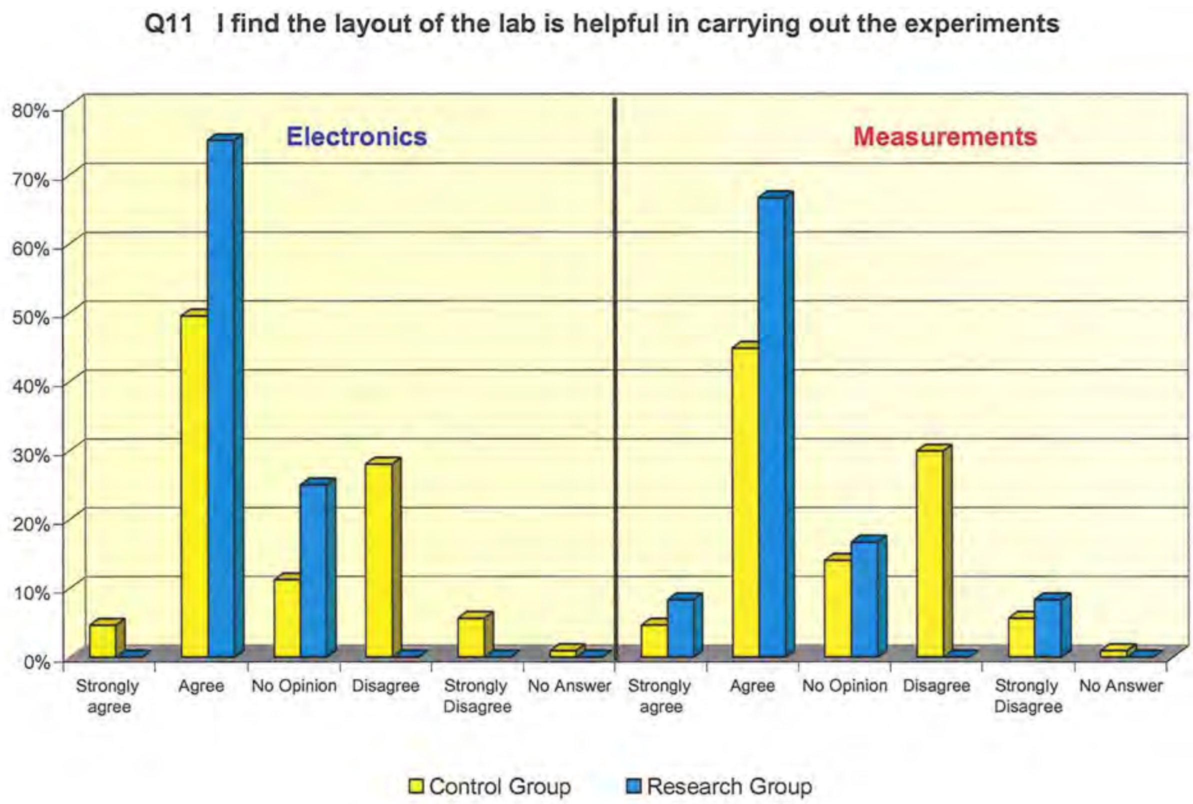

Figure 4.11 Question 11

The results of question 11, about the layout of the labs, are shown in Figure 4.11. The results for the control group for the electronics and measurements labs are very similar, with *agree* figures of 49% and 45% respectively. The figures for the research group are also very similar for both the electronics lab and measurements lab, being 74% and 67% respectively. The research group figures are very much higher than the control group figures.

Question 12

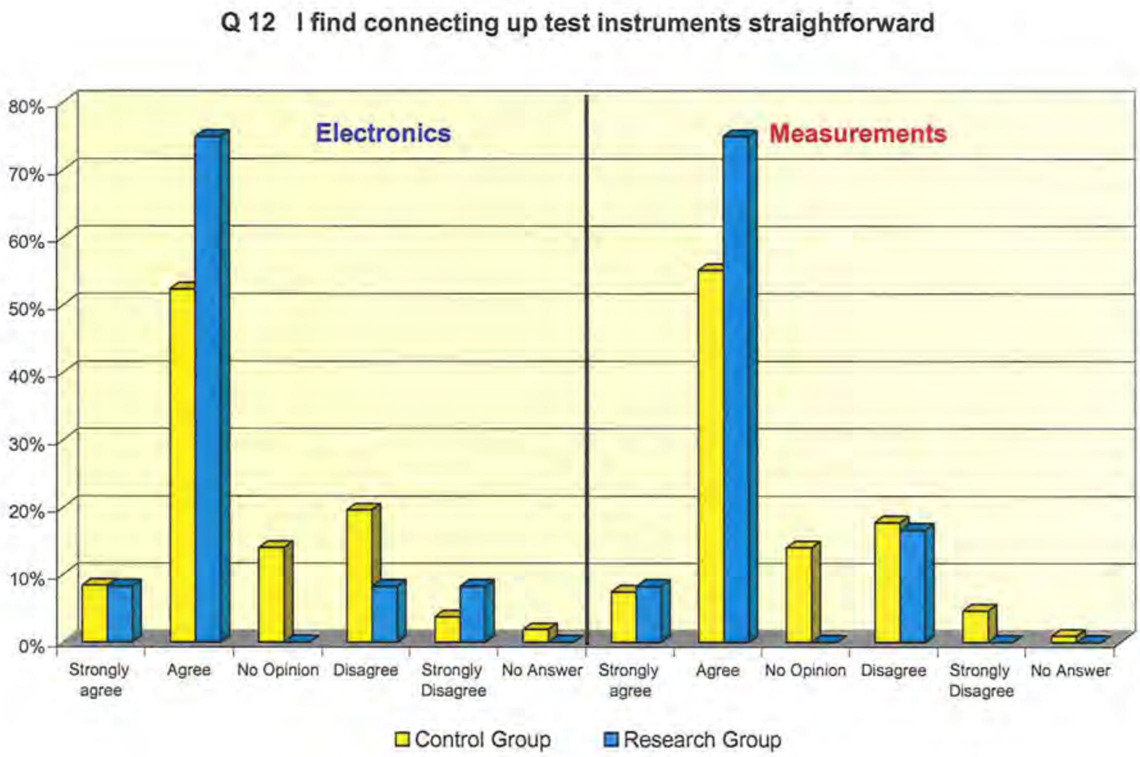

Figure 4.12 Question 12

Question 12 dealt with the students' opinions of connecting measuring instruments. The results are shown in Figure 4.12. As in question 11, the figures for the control group for both the electronics and measurements labs are very similar, the *agree* figures being 52% and 55% respectively. The figures for the research group are also broadly similar. At 75% each for the *agree* figure, they are one of the highest values achieved in the questionnaire. The *strongly disagree* figure for the electronics was 8%, compared to 0% for the measurements. This topic of connecting instruments is also discussed by the students in both the focus group session and the individual interviews.

Question 13

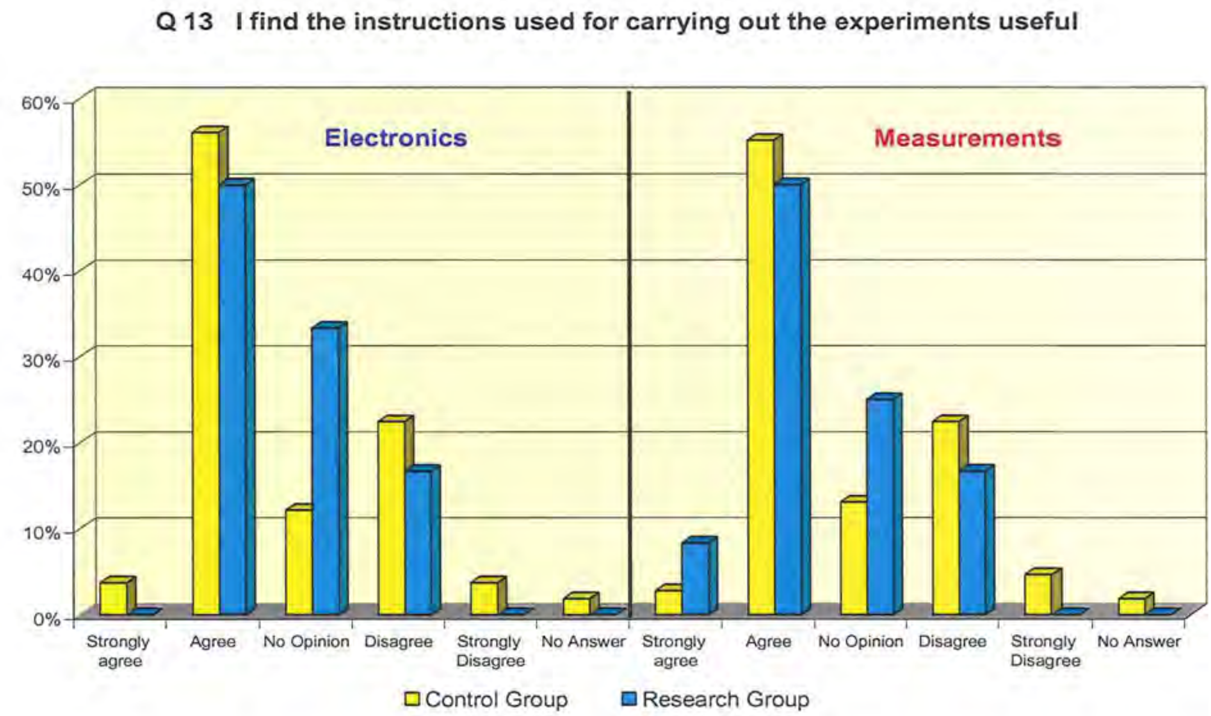

Figure 4.13 Question 13

Figure 4.13 shows the results for question 13, dealing with the usefulness of the instructions for the experiments. Again, as in the previous two questions, the results for the control group for both the electronics and measurements are very similar, being 56% and 55% respectively for the *agree* figures. The *disagree* figures were both 22%. For the research group, the figures for the electronics and measurements were again very similar. The *agree* figures were both 50%. The *strongly agree* figure for the electronics was 0% while the corresponding figure for the measurements was 8%. The *no opinion* figures were high at 33% and 25% respectively. During cycle one of the research there were no formal instructions provided in the labs.

Question 14

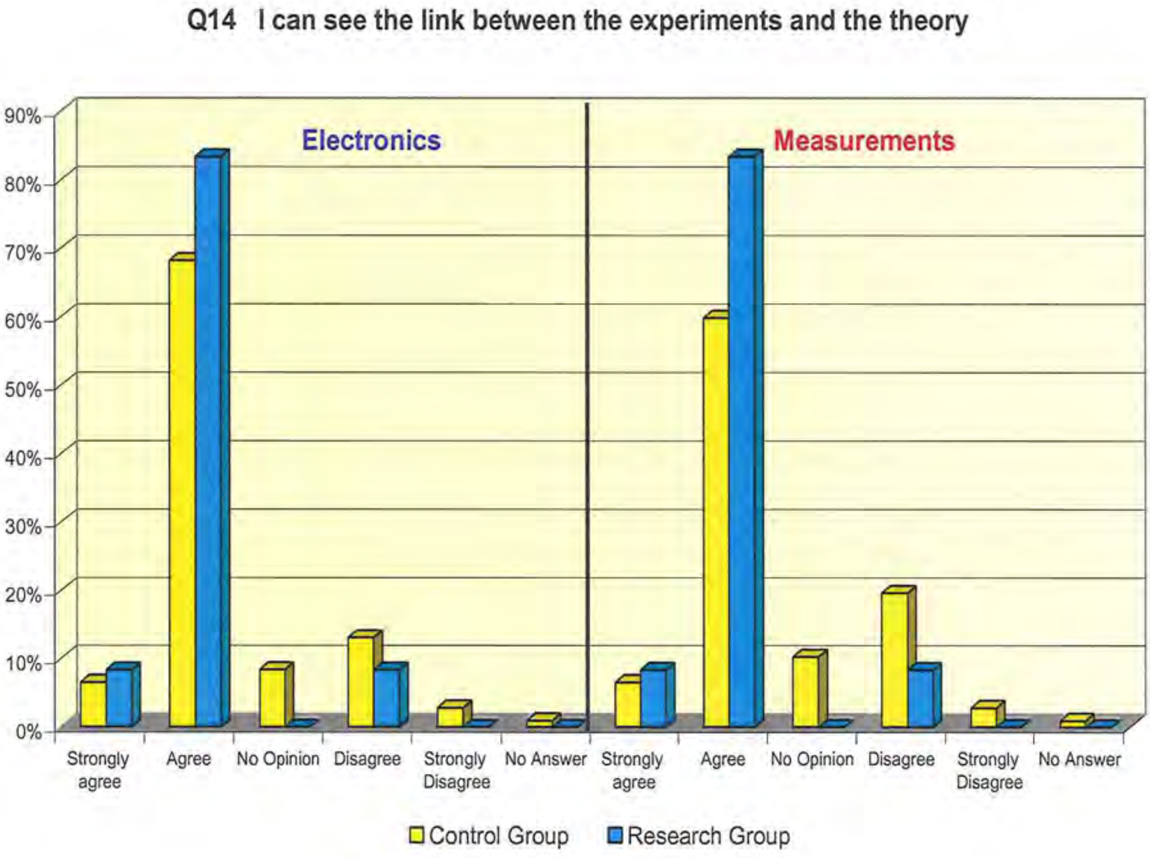

Figure 4.14 Question 14

Figure 4.14 shows the results of question 14. This question is very similar in nature to question 8 and deals with the principles of the experiments. The results for the control group are similar for both the electronics and the measurements lab. The *agree* values are 68% and 60% respectively. The other opinions have broadly similar results. For the research group the *agree* figure is very high at 83% for both the electronics and the measurements labs. This is much higher than the control group value.

Question 15

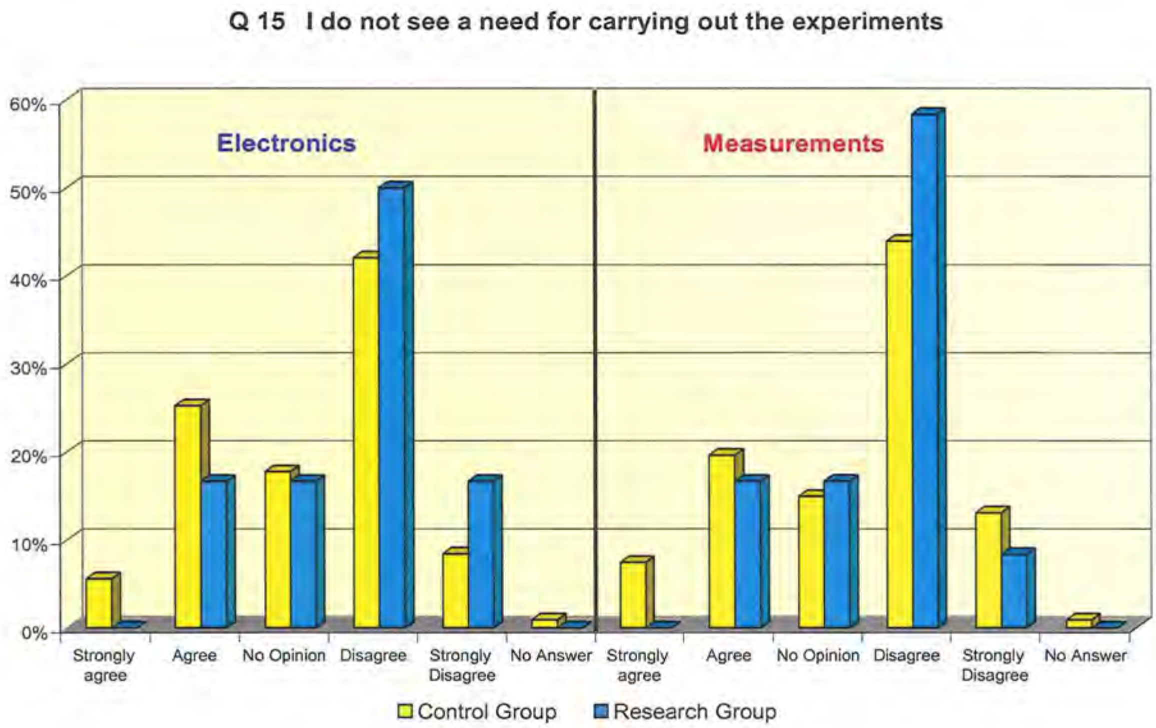

Figure 4.15 Question 15

Figure 4.15 shows the results for question 15. This question is similar to question 7, except that it is asked in a negative format, to check if the students were actually reading the questions, rather than just ticking the same boxes for all the questions. As was the case in many of the previous questions, the results show a strong similarity between the electronics and the measurements labs, for the control group. For this question the highest values are for the *disagree* option. The values for the *disagree* option were 42% and 44% respectively. For the research group the *disagree* option shows a higher value, being 50% for the electronics and 58% for the measurements lab. The other options show broadly similar results.

Question 16

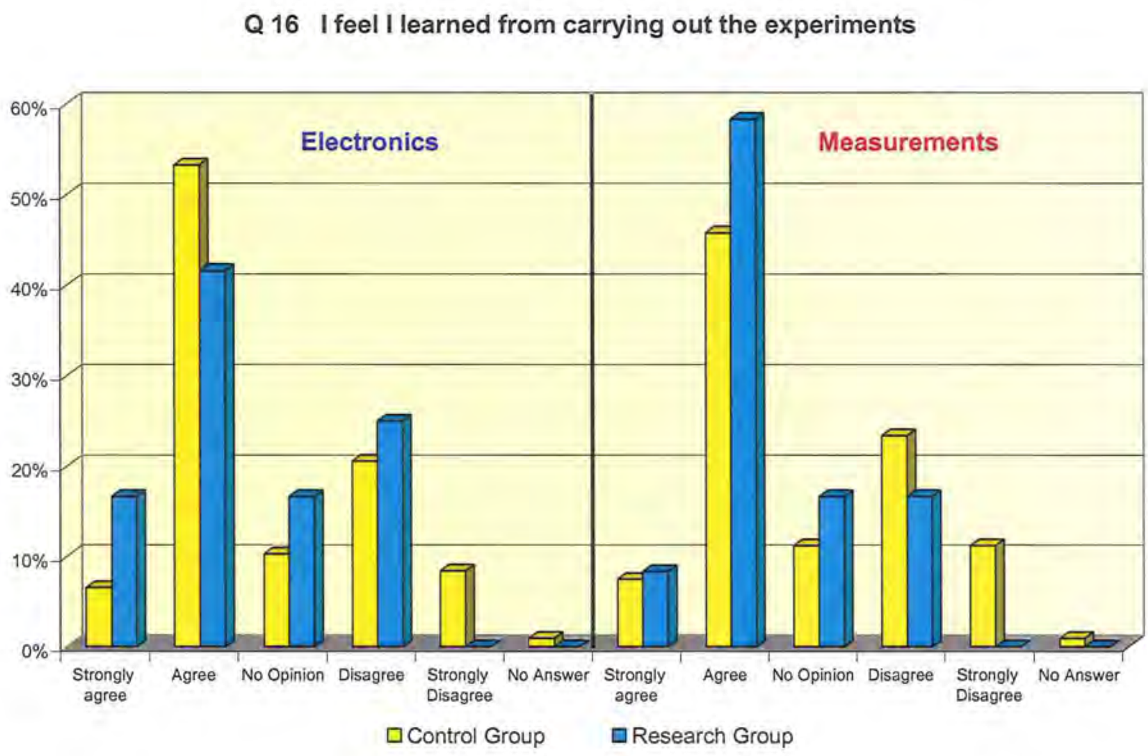

Figure 4.16 Question 16

The results of this last Likert scale question are shown in Figure 4.16. The students were asked if they felt they had learned from the labs. The control group figures for the electronics and measurements are again broadly similar. The *agree* option values were 53% and 46% respectively. The *disagree* option figures were 21% and 23% respectively. For the research group the *agree* option figures were 42% and 58% for the electronics and measurements respectively. The *disagree* option figures were 25% and 17%. The research group felt they had learned more from the measurements than from the electronics.

In general, the Likert scale questions in the questionnaire showed very few strong opinions, positive or negative, on the topics covered. The two topics that elicited the strongest positive responses were working as part of a group, question 9, and having sufficient time to complete tasks, question 10. Question 15 was included to check if the students were reading the questions carefully on the questionnaire. It is similar to question seven, except that it is in a negative format. This question gives the highest value of *disagree* responses. This is in line with the suggested format for questionnaires as outlined by Foddy (1993) where the same question should be asked twice but the second time it should be in a negative format. The results from the two questions can then be compared to see if the same opinion is being expressed each time. This question appears to confirm that the students were indeed expressing the same opinions and can be regarded as being valid.

Open Ended Questions

The questionnaire finished with four open-ended questions. Question 17 asked the students to write what they liked most about the electronics and measurements labs. Question 18 then asked what was liked least about the labs. Question 19 asked for suggestions about improving the labs. Finally, question 20 asked for any other comments.

The response rate to questions 17 and 18 are shown in Figure 4.17. The figures show the percentages of the students who made some reply to questions 17 and/or question 18. The charts for questions 17 to 20 refer only to the control group of students. The results for the research group are shown separately because of the very low level of response from the research group.

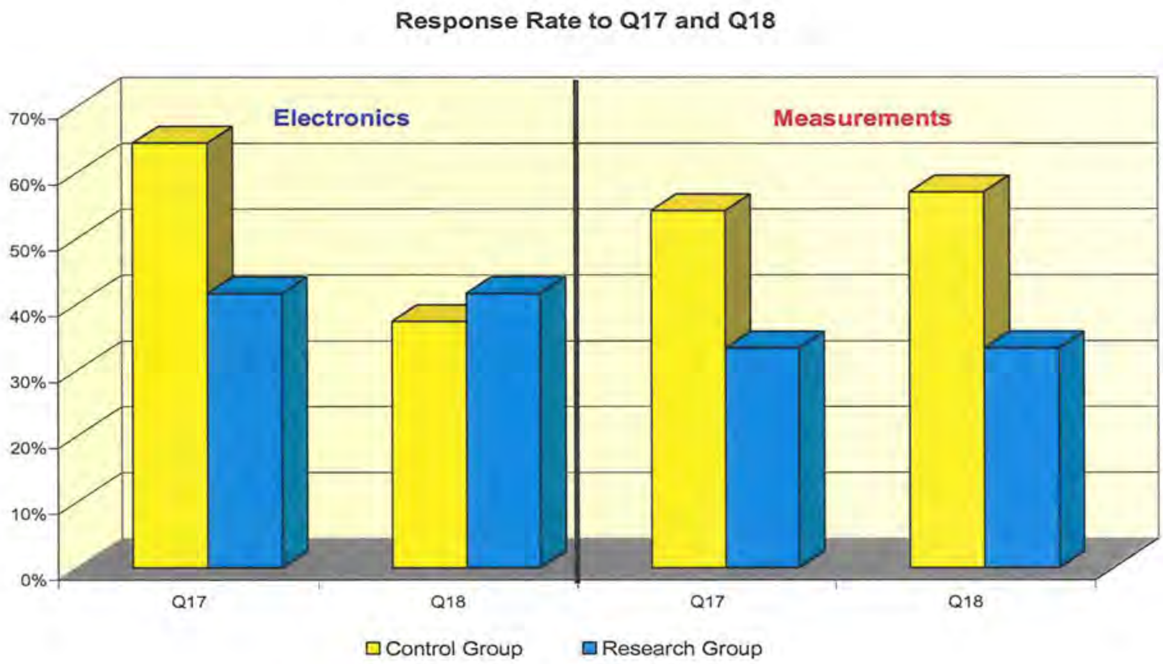

Figure 4.17 Response rate to questions 17 and 18

The answer to each question was first reduced to a key phrase or phrases. Each phrase was then assigned a code number. The phrases were then examined to detect common themes. These themes were then grouped together and reduced to seven overall categories for questions 17 and 18, and five categories for questions 19 and 20. The number of occurrences of each of the main categories was then converted to a percentage of the total number of replies received for each of the four questions

The replies for question 17 initially consisted of 32 different phrases. These were then further analysed and reduced to a smaller number of main themes. These themes are shown in Figure 4.18.

Question 17

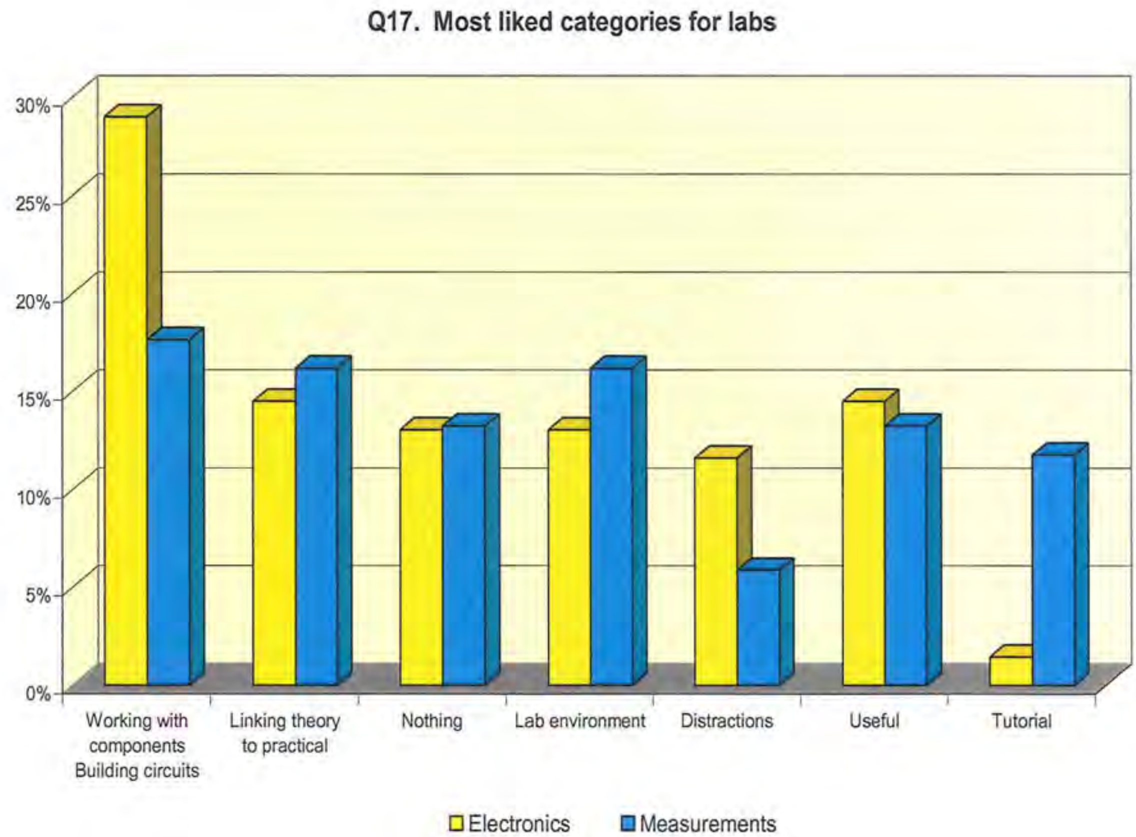

Figure 4.18 Question 17

The percentage figures are those students who referred to that particular topic from the actual number that replied to question 17. The item most liked by those who replied to question 17, in both the electronics and measurements, was the hands on practical work with the components and circuits. The linking of the theory element of the course to the practical applications of this theory was the second highest category. Some 13% indicated that they liked *nothing* about either the electronics or the measurements labs. The *lab environment* refers to the physical layout of the lab itself. The comments referred to items such as the "*nice chairs*", "*adequate space to work in*", and "*layout of tables*". The *distractions* refer to any activity that was not connected to the lab topic, such as "*talking*", "*sleeping*" "*thinking about breakfast*", and "*misusing equipment*". The *useful* category refers to comments such as the exercises or lecturer being "*helpful*", "*interesting and helpful*" and "*learning something different*". The last category of *tutorial*, refers to comments concerning other topics covered by lecturers in the lab classes, such as "*revision*" and "*answering exam questions*", that were not directly related to the aim of carrying out practical work.

Question 18

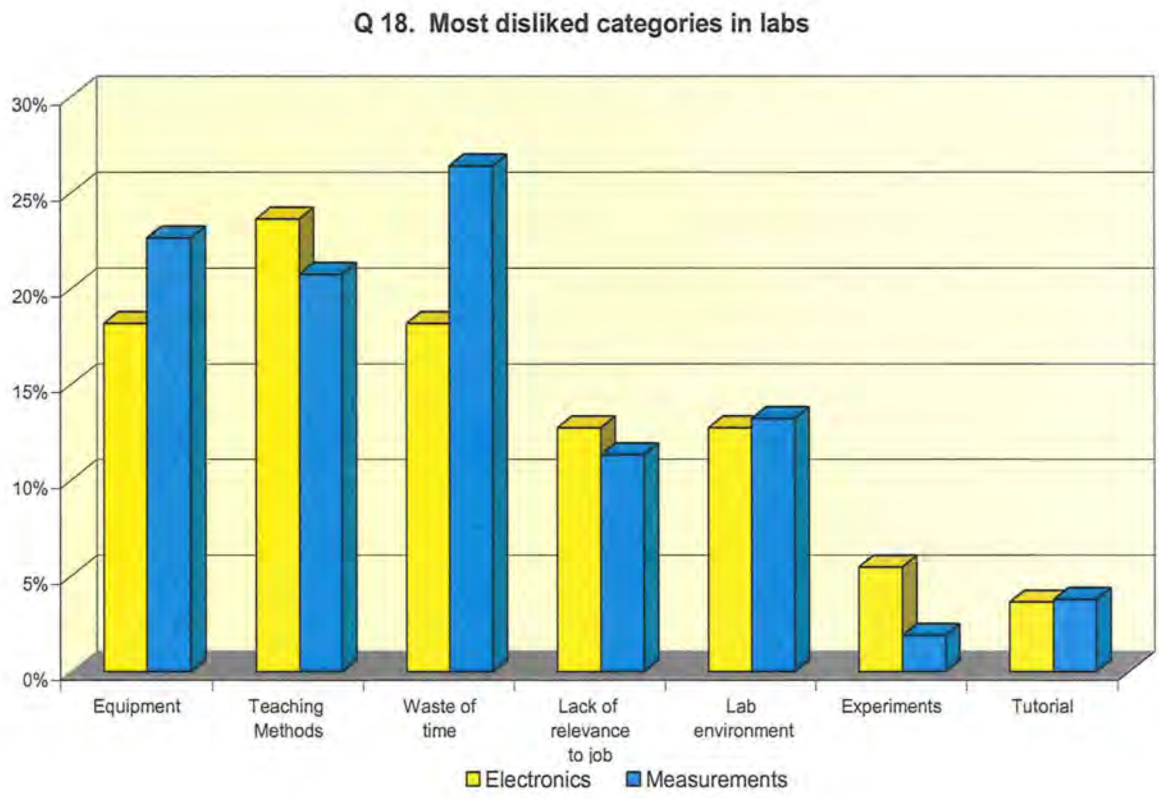

Figure 4.19 Question 18

The answers to question 18 received the same consideration. There were initially 37 different phrases. Again, by careful analysis these were reduced to seven main themes. The results are shown in Figure 4.19.

The *equipment* used in the two labs was not perceived to be adequate for the tasks in the labs. Terms such as "*outdated*", "*lack of*", and "*unsuitable*" were used. *Teaching methods* included all comments about lecturers and actual teaching methods. Again, a wide range of comments were used such as: "*lack of proper teaching*", "*no organisation*", "*not enough theory*", and "*using different teachers*". 18% of students, who answered the question, thought the electronics lab was a "*waste of time*". For the measurements lab, this figure was 26%. The *lack of relevance to job* category showed a value of 13% for the electronics and 11% for the measurements. The *lab environment* category included comments such as "*run down*", "*broken seats*", "*too small*", "*holes in the walls*", and "*set up*". The *experiments* category included comments such as "*not enough*" and "*oscilloscope*". The term *tutorial* again refers to other topics covered in the lab classes such as "*no lab work*" and "*revision*". The figures for *tutorial* dislikes was 4% for both the measurements and the electronics.

Question 19

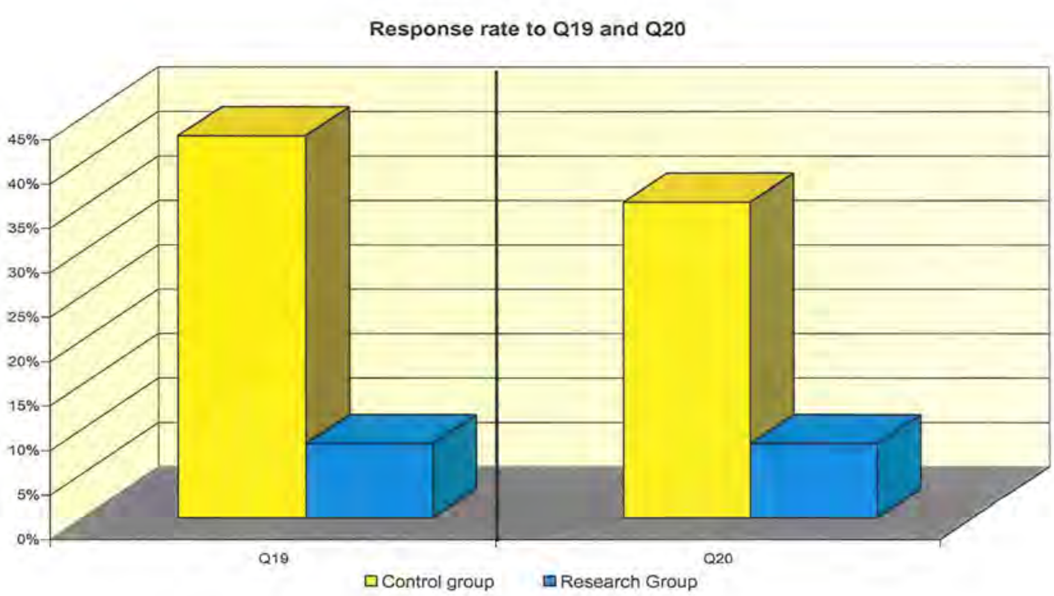

Figure 4.20 Response rate to questions 19 and 20

The response rates to question 19 and question 20 are shown in Figure 4.20. For the control group the response rate to question 19 was quite good at 43%. For question 20, it was lower at 36%. For the research group, however, the figures were much lower at 8% for both questions 19 and 20. The results for questions 19 and 20 shown in Figures 4.21 and 4.22 are for the control group only, because of the low number of replies from the research group. For question 19, there were initially 22 different responses. These were further analysed and reduced to five main themes.

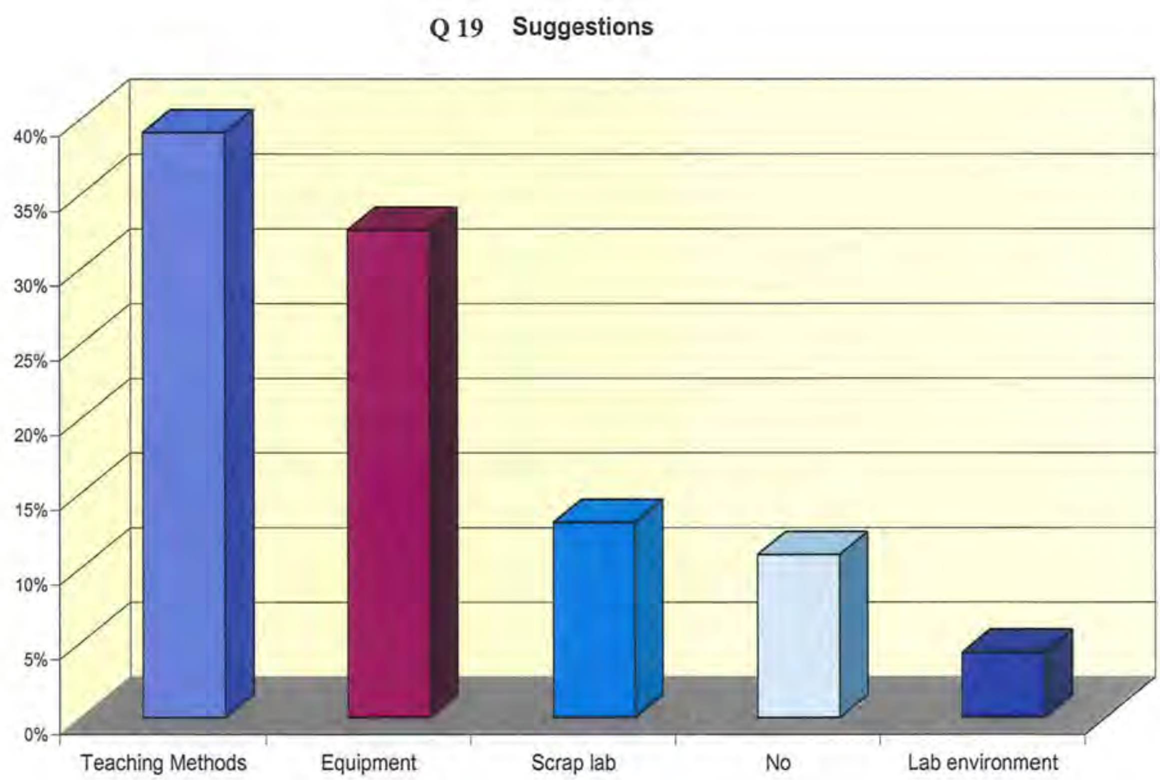

Figure 4.21 Question 19

The *teaching methods* category was the largest with 39%. This category includes any comments about lecturers and types of activities that such be included in the lab. The suggestions included "*change to tutorial class*", "*make it interesting*", "*more relevant tests*", "*better teacher*", "*work individually in lab*", "*use exam questions to understand* *circuits*", and "*carry out more tests*". The next category of *equipment* accounted for 33% of the suggestions. It included any references to lab equipment, such as "*use cut away models of items*", "*new equipment*", and "*more equipment*". The next category of *scrap lab* refers to any comments about getting rid of the lab completely. 13% of suggestions referred to doing this. Comments included "*scrap it*" and "*turn it into pool room*". The *no* category refers to any reply that had "*no*" in response to the question. Better wording of the question would probably have avoided this type of answer. The last category, *lab environment*, referred to any suggestions to improving the room itself, such as "*more heat*" and "*paint lab*".

Question 20

Question 20 on the questionnaire asked for any further comments. From the 40 replies received, there were initially 16 different comments. These were then further analysed and reduced to five main themes. The results are shown in Figure 4.22.

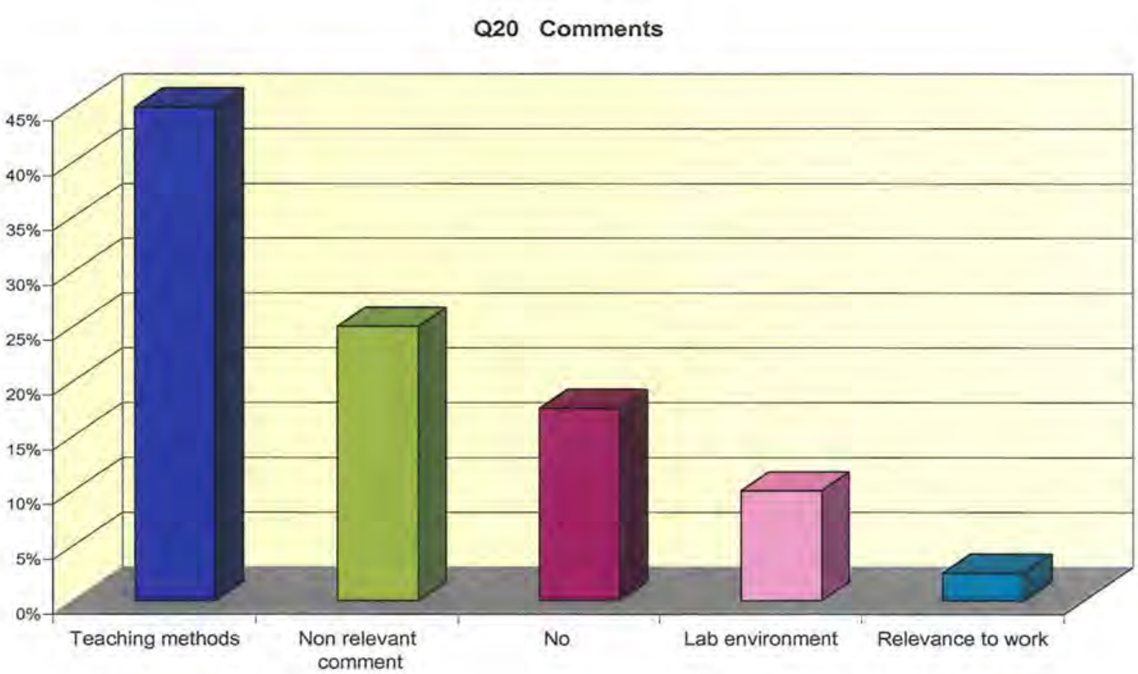

Figure 4.22 Question 20

The *teaching methods* category accounted for 45% of the comments. These included comments such as "*include tutorial class*", "*unsuitable teaching methods*", "*use it for exam revision*", "*some lecturers unable to see subject from student point of view*", and other lecturer comments. The *non-relevant comment* category included all comments that had no relevance to the two labs in particular or the phase six course in general. These included some comical and some derogatory comments. The *no* category accounted for 18% of comments. As was stated for question 19, a better choice of wording may have avoided the *no* comments. The *lab environment* accounted for 10% of the comments. These included "*modernise lab*" and "*fix walls*". The final category of *relevance to work* accounted for 3% of the comments and included the comment "*lab not relevant to work*".

Results for the Research Group

The research group made very few replies to questions 17 to 20. For question 17 there were five replies and question 18 also had only five replies. For question 17 two students liked "*working with components*" and circuits, two liked the "*links to the theory*" and one liked "*nothing*" about the electronics lab. For the measurements lab, three liked the "*building of circuits*", one student liked the "*linking of theory*" and practical and one student liked "*nothing*" about the measurements lab. The same three students commented on the dislikes for the two labs. The comments were "*not knowing more about it*", "*need more notes*" and "*too much talking*". The percentage figures shown in Figure 2.23 were out of the numbers who actually replied to the questions.

For questions 19 and 20 only one student wrote any comments. For suggestions about improving the labs he suggested working individually. He made the same comment for question 20, stating that "*... it would have been a lot more helpful as I wouldn't have been talking as much*".

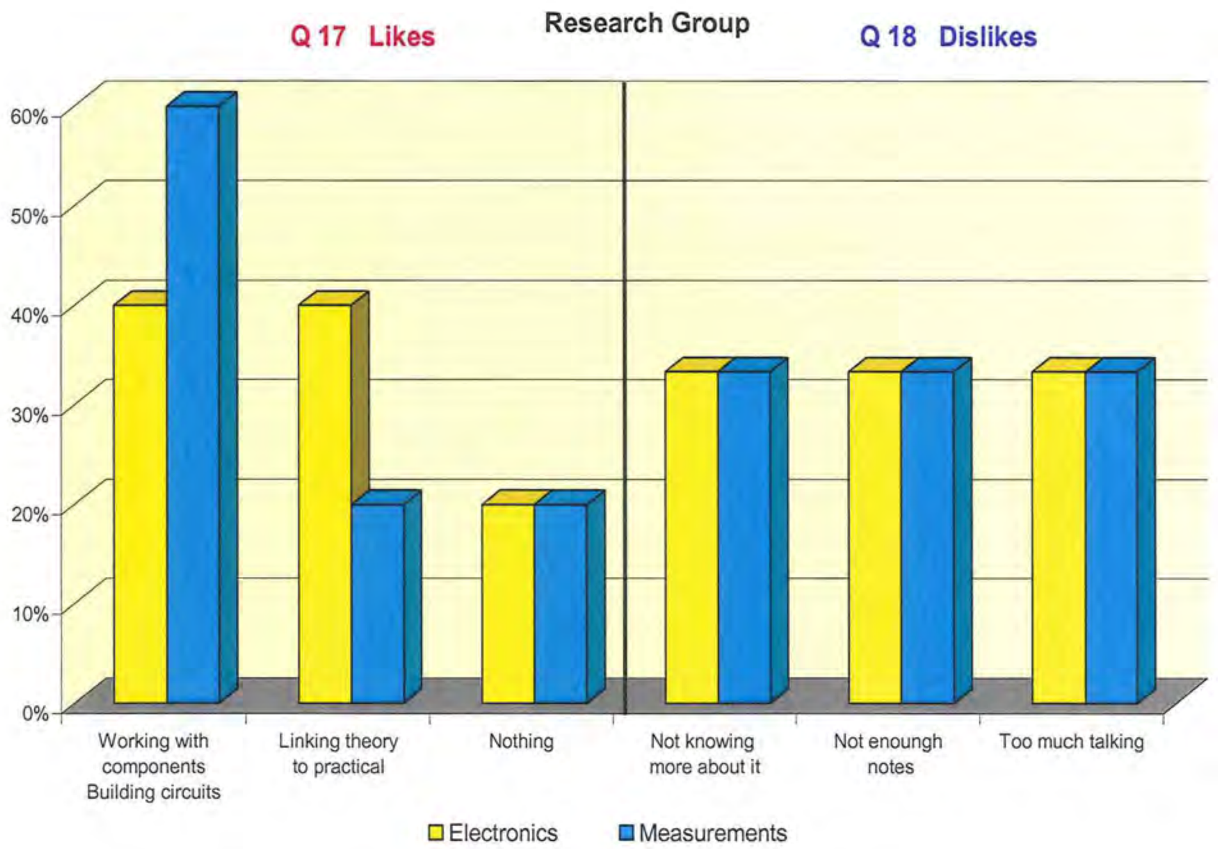

Figure 4.23 Research group questions 17 and 18

It was disappointing to have had so few comments after two cycles of the action research. It made comparing the results of these questions from the control and research groups very difficult.

4.5 Analysis of Lab Feedback Sheets

There were sixteen students in the research group. In theory, I should have received thirty two feedback sheets after each week's sessions. Some students however, felt that they did not wish to participate in filling out the feedback sheets. While I would have preferred them to do so, I did not want to be seen as exerting undue influence on them to do so. I encouraged the group to fill them in as much as possible but, as can be seen from the results, the level of completion declined as the research progressed. There are seven weeks of results shown. These are for week one to four and week six to eight. There were no feedback sheets for weeks five and nine. These were the weeks the focus group and individual interviews were recorded.

Foddy (1993) suggests ways of showing data from questionnaires. One topic that is discussed is the idea of the overall positive feeling. Each response is assigned a number. The more positive a response the higher the number. The values from each question are added and an average found and used as a positive indicator. This was done for the lab feedback sheets. For a strong positive feeling, the score was 5. For a positive feeling, the score was four. For no opinion, the score was three. For a negative feeling the score was 2 and finally the score for a strong negative feeling was 1. The results are shown in Figure 4.24. The results are based on the actual number of feedback sheets received, which during the second cycle, weeks 6, 7 and 8, were very low. It can be seen that the positive feeling starts quite well for the electronics lab and increases in week two. After this, it declines each week. The results for the electronics lab are higher in each week than for the measurements lab. The final results were about a third of the initial value.

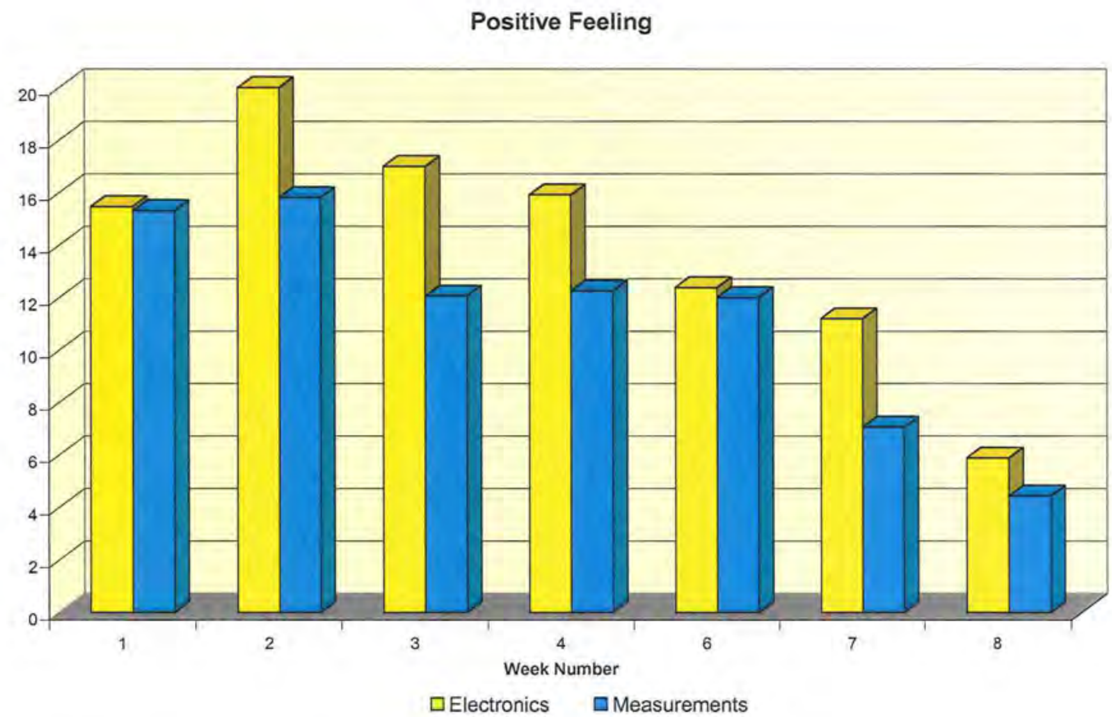

Figure 4.24 Positive feeling for labs

The results of the feedback sheets, for the seven weeks that they were returned, are shown in the following charts. The results for each question are shown over the seven weeks. The *agree* option is highlighted in yellow to make identification easier. Only the results for the electronics are shown. There were some differences between the electronics and measurements but these were not dramatic. The electronics data was generally slightly more positive than the measurements, as can be seen from Figure 4.23.

Question 1

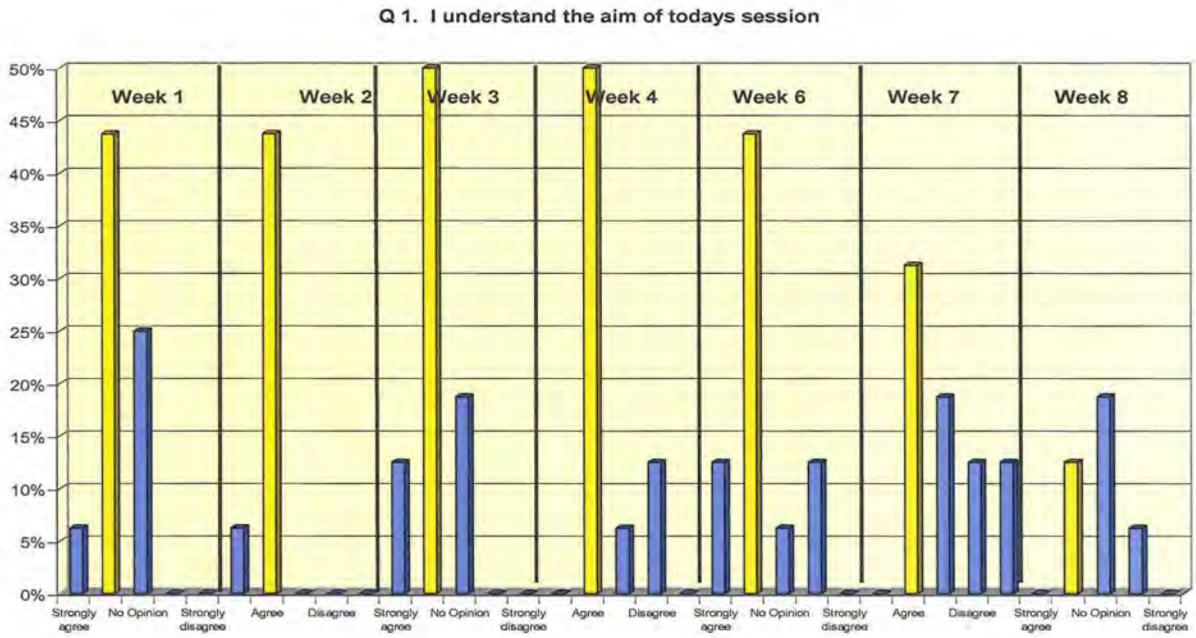

Figure 4.25 Question 1 Lab feedback sheet

The *agree* option has the highest figure for all weeks, except week eight. The level of *no opinion* varied between 25% and 6%, but for the last two weeks of the course remained high, at 19%. The aims of each lab session were explained at the start of each session and were very important for understanding the reasons for carrying out the lab work. The level of response on the lab sheets declined as the course progressed.

The focus group was recorded in week 5 and the interviews were recorded in week 9. No feedback sheets were received for these weeks.

Question 2

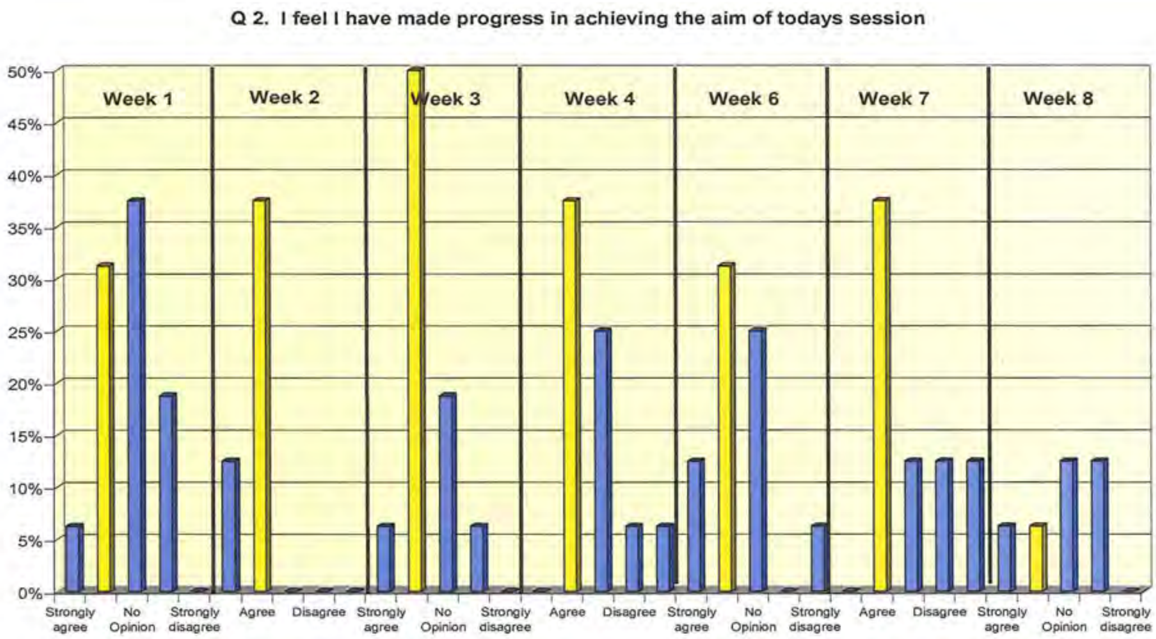

Figure 4.26 Question 2 Lab feedback sheet

Question 2 asked about progress in achieving the aim of the session. As can be seen from Figure 4.26, the level of *agree* options was high, apart from week 8 when the level dropped to 6%. Since initially the problems would have continued over two or more weeks, this question was included to allow the students to feedback on how they felt as they were progressing each week, even if a solution to the problem had not been fully achieved.

Question 3

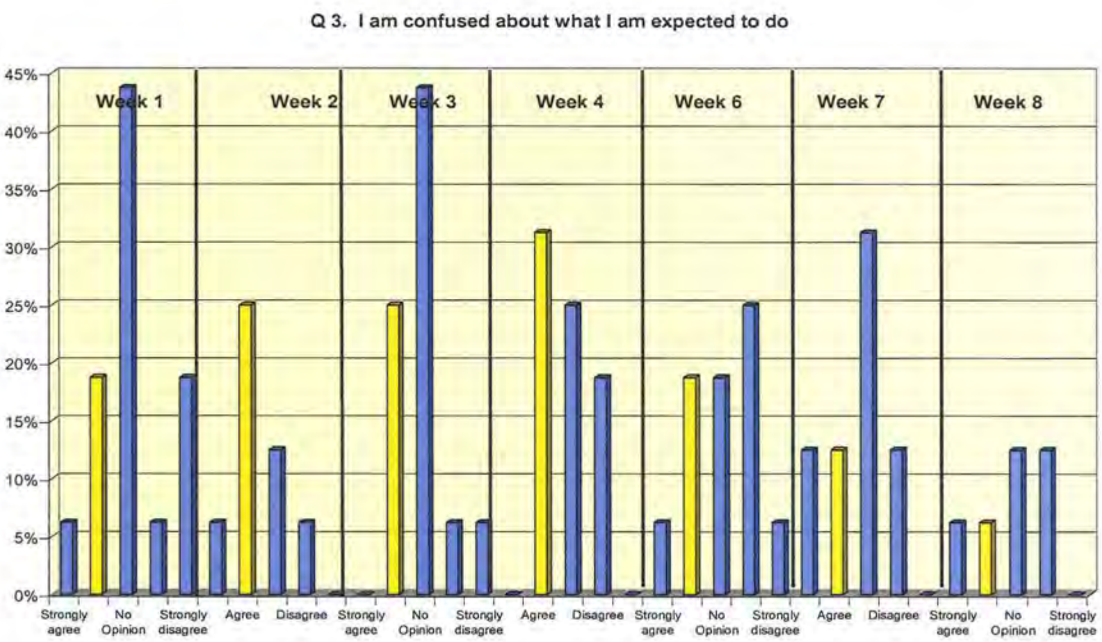

Figure 4.27 Question 3 Lab Feedback Sheet

Question 3 generated a very high level of *no opinion*. Only week four showed a higher level of *agree* than *no opinion*. The figures would seem to indicate that the students did have some understanding of what they were attempting to do, rather than being totally confused. Week four is when the students voiced their concerns over the methods used in the labs and this would account for the higher *agree* figure for that week. As with all the questions on the feedback sheet, there were very few strong opinions either for or against the statements.

Question 4

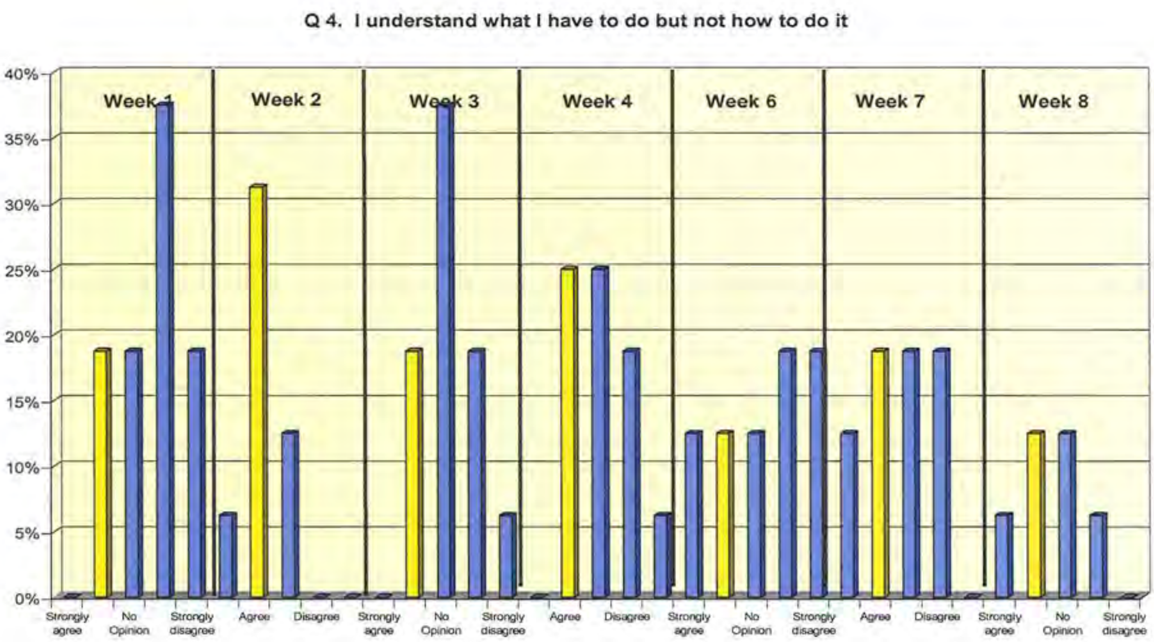

Figure 4.28 Question 4 Lab feedback sheet

The response to this question varied considerably. In week 1 there was a high *disagree* figure of 38%. By week 2 the *disagree* figure dropped to 0% and the *agree* figure rose to 31%. By week 3 the *no opinion* figure rose to 38%. In week four the *agree* and *no opinion* figures were both at 25%. For weeks 6, 7, and 8 the figures for *agree* and *no opinion* equalled each other. The figures show a very confused trend. This is probably due to the way in which I worded the question. Disagreeing with the question could mean the students knew how to carry out the task but it could also mean that they did not understand what to do. It is more probable that they did not understand what it was they had to achieve for the lab session. It would have been preferable to have had each question dealing with one aspect of the class only.

Question 5

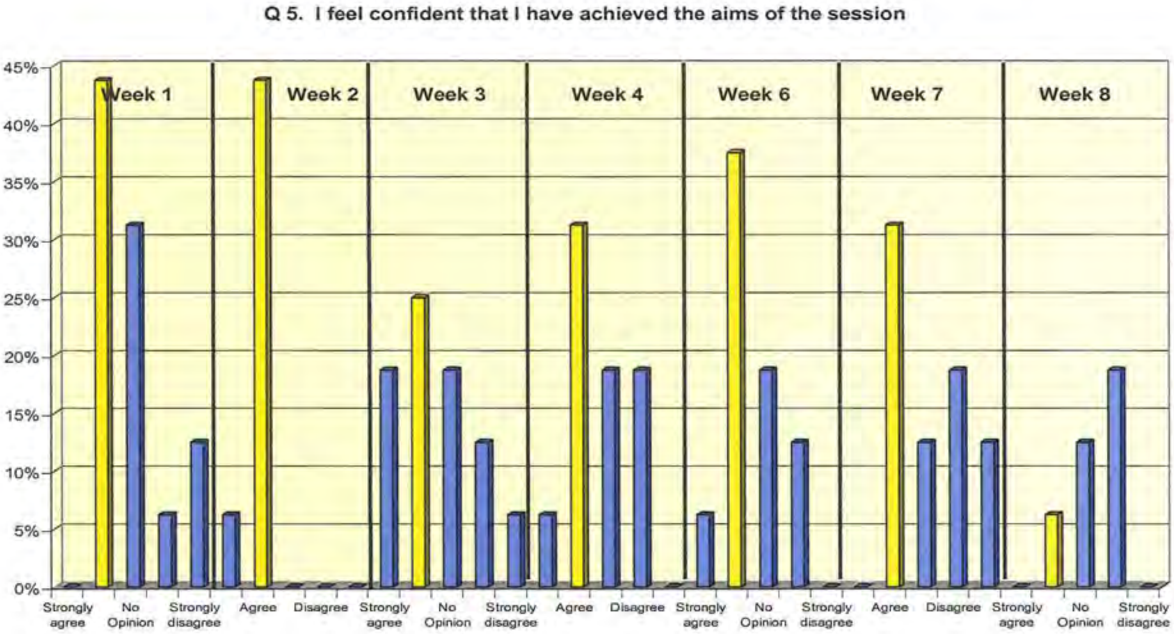

Figure 4.29 Question 5 Lab feedback sheet

Question 5 asked about the confidence in achieving the aims of the session. The *agree* figure was the highest for all weeks except the last. Confidence levels were high for the first two weeks. They dropped for week 3 but peaked again in week 6. The *no opinion* figures were reasonably constant for the last five weeks of the study. The aims were explained at the start of each session so that the students would have an understanding about what they had to achieve. The chart indicates that the students felt they had achieved the aims. The values in week 8 again show a very low *agree* figure, mainly due to the low response rate for that week of the research.

4.6 Action Research Cycle One

Week 1 13th January 2005

The first action research cycle began in the electronics lab. I introduced myself to the group of 16 phase six electrical apprentices. I explained the purpose of the electronics lab and the fact that I would like to carry out research with the group. I explained carefully the type of research, the reasons for doing it and the benefits they may gain from it. I also assured them that they would not be placed at any disadvantage by being part of the research and that they could withdraw from the research at any time if they felt that the research was having an adverse affect on their learning. This point was significant as will be seen later. They then all signed the sheet informing them of the type of research being carried out and their agreement to it. A copy is provided in Appendix C.

The constructivist approach adopted in this study involves allowing students to build up their knowledge, to make discoveries, to use primary sources of information, to see the 'big idea', to question, and to work in groups (Brooks and Brooks, 1993). The first topic I wanted to look at was an electronic device called a Thyristor. The normal format for the lab is to give the students a quick run through of the theory of the working of the device. Then they are given a circuit to build and get working and then record a certain set of results. Instead of this format, I gave them a circuit containing a thyristor and asked them about the circuit. As was expected, none could describe how the circuit operated. I then asked about the individual components and if they could recognise what they were. All could recognise the components apart from the thyristor. Then, working in groups of four students, I asked them to write what they knew about the components they recognised. When this was complete, we discussed the individual components and how they had used them previously. We made slow progress. Eventually, we managed to agree that they had used them before and could remember some of the information about them. They seemed to find this a strange process. In the research journal that I kept for this study, at this time, I used the phrase "*The information did not flow freely, it had to be extracted"*. We carried on and looked in more detail at how the components could be used in the circuit with the thyristor. That took us to the end of the first electronics session. I then asked the students to fill out the feedback sheet for the lab. Fifteen of the students did so. The results were reasonably positive. The maximum value that could be achieved is 25. For week one of the electronics the value was 15. No dislikes were listed and only three comments were made: "*getting there*", "*slow, little learned*" and "*utterly lost*".

For week one of the measurements lab, I started by giving each of the four groups a problem to look at. A sample is provided in Appendix E. The theory was to let the students develop possible solutions and locate the information for themselves. Textbooks, notes, handouts, and the National Rules for Electrical Installations could be used to source this information. The level of interest in trying to develop solutions to the problems was disappointing. If I pressed the students to examine a topic, they would do so but as soon as I left the group to their own devices, all efforts stopped. I did not expect the students to be very competent at this sort of task as it is not the normal teaching practice. I was, however, hoping that the level of interest would have been higher. I wrote in the research journal for this session, 13th Jan 2005: "*For the first day of a lab we achieved very little in the way of experiments. I expected this but I don't think the students did"*. Eventually by posing questions and stressing what the groups already knew, we were able to suggest possible solutions to the problems. We would then try these solutions by building circuits the following week. A slow start was made but as this was new to the students I felt that it would become clearer. At the end of the session, I received 15 completed feedback sheets. No dislikes were listed and only one comment was written: "*very slow moving, no progress"*. The slow moving part was certainly true but some progress had been made. After reviewing the feedback sheets, I resolved to reassure the students that they were making progress and that they had the ability to succeed in this process.

Week 2   20th January 2005

The electronics lab started by the students asking a question about mixing A.C. and D.C. signals. I ran through the explanation of what occurs and how it can be shown on the oscilloscope. The students seemed to understand the explanation. This seemed encouraging, as they had actually initiated the discussion. We then progressed to thyristor again and how it operates on both A.C. and D.C. supplies. The groups had components that could be used to construct simple circuits to use the thyristor as a switch on both A.C. and D.C. I then asked them to build these simple circuits and record what they observed. After some initial confusion, they were able to do this and observe what occurred. Now that they had some basic information, I asked them to come up with a description of how the thyristor would operate under different conditions. This was accomplished once I stressed that what they had observed from the exercise was all they needed. Now that they had observed how the thyristor behaved with different types of supply, I asked them to come up with a definition about how the thyristor worked. At this point, I had written the word *confusion* several times in the research journal about this session. The concept of trying to figure things out was still new to the students. However, after a few attempts, they came up with an accurate description of how the thyristor worked. Success, but the students did not seem to have a sense of having achieved anything. They said that if I had just given them the information, then it would have taken a lot less time. I asked if they had learned from the process. They replied that they had but it could have been quicker. So far, they had not appreciated what I was trying to achieve with the process. No comments were made on the feedback sheets. The positive feeling value for the electronics was 20.

In the measurements lab the students still waited for instructions. When I was with each group, they made progress. I went through the completion tests with two of the groups and explained three phase voltages to the other two groups. They carried out exercises to confirm what they believed were acceptable solutions to the problems I had given them. The exercises confirmed what they believed to be correct. Unless I told them to write down specific pieces of information, they did not do so. Progress was being made but only with a lot of shoving in the right direction. I concluded the journal entry for that session by writing "*I will persevere*". I assumed it would take time to accept the different way of learning but so far, there appears to be little enthusiasm for it. From the feedback sheet for the labs, the only comment returned was "*still confused*". The positive feeling value for the measurements it was 16.

Week 3 27th January 2005

In the electronics lab, they were all asked to build the motor speed control circuit that I had given them on the first day. They all started willingly but after a short time, their attention began to wander. Like previous sessions, if they became stuck on anything then everything stopped until I came back to the group. Some students still found it difficult to relate the circuit diagram to the building of the practical layout on the electronic boards. After some questioning about various connections, they all managed to build the circuit and they all worked. Just after finishing the circuit, some of the students asked a question about what they had covered in theory that morning. I went through an explanation of the topic. I was surprised that they all listened carefully. This seemed to be a particular topic that none of them had managed to grasp from the morning session. Now they were all very attentive and willing to listen carefully. They all seemed content with the explanation and that it was not quite as complicated as they thought it was going to be. No comments were made on the feedback sheets. The positive feeling value for electronics was 17.

For the measurements lab I allowed two of the groups to present to the other groups the solutions they had found for the problems they were working on. I asked them questions about how they came up with the solutions and the importance of them. All the other groups listened and appeared to find it useful. I had, however, to remind them to write down the important points, so as not to lose the information. One point, that did come from the discussions was, that they found the process of looking for information difficult to deal with. They preferred to have the information given to them.

The majority of students appeared to agree with this. I did point out that it was new to them and that it would take a little time to judge the method fairly. I also, again, stressed the need to fill in the feedback sheets carefully so that a reliable idea of how they see the lab classes could be gained. The only comment from the feedback sheets, for week three, was that some students would not stop talking. The positive feeling value for measurements was 12.

Week 4 3rd February 2005

In the electronics lab, I started by giving the students an amplifier circuit to power up and connect to various test instruments. They had already covered the theory for the circuit in a separate class. The greatest difficulty was with the oscilloscope, so I spent some time recapping how it could be connected and used to measure voltages and frequencies. All the groups were able to get the circuit wired correctly, with just a few prompts in the right direction. They were then able to measure and record the values from the amplifier. Once they had the results, they were unsure what to do with them. Once again, it was the relevance of the information that was difficult for the students to see. The actual carrying out of tasks, in most cases, did not cause them any great difficulties. The practical tasks of connecting instruments were usually straightforward except where the students had not seen particular instruments before. On the feedback sheets for week four the only comment received was that one student had not seen a combined A.C. and D.C. signal on the oscilloscope. The positive feeling value for the electronics was 16.

For the measurements lab, two groups were investigating the earth electrode resistance and the remaining two were confirming the completion tests. The same problem as before occurred. While I was with the group, they worked well but as soon as I left to attend to another group, the work ceased. It was clear that it was not a problem of being unable to proceed with anything. As soon as I asked them questions about was the next step to be considered, they were able to make suggestions. They still seemed easily distracted and unfocused. Once they managed to locate the information from the available sources, they were still unsure how to use the information correctly. It was this point that was becoming very clear. In the research journal for this session, I had written, "*I've noticed again that once the information is found they are not quite sure how to interpret it*". I then spent most of the remaining time explaining how the data is used to show if the readings are within safe parameters. No comments were made on the feedback sheets. The positive feeling value for measurements was 12.

Towards the end of the session, I had a talk with the whole group to allow them to express their own views on progress to date. The majority expressed the view that they were carrying out the investigations badly and did not wish to continue doing them. They said they were used to seeing step-by-step instructions and that is what they preferred, as a method. It was quite clear from observing the students in action over the four weeks, that there was little enthusiasm for the investigation process. I had hoped that they would get used to the process. It was now clear that this was not going to happen. I had agreed with the students on day one that if they did not feel comfortable with what was taking place during the research, then I would change what we were doing. To use the words I wrote in the research journal "*That time has come*".

At this point, I had to reflect carefully on how to deal with the situation. I agreed with the students that we would stop the investigation type process and that I would talk to them again the following week. I then returned to the literature about practical work and looked again at its aims and effectiveness. Millar (2002, 2004) states that one of the main aims of lab work is to make the link between two domains, the domain of real objects and observable things and the domain of ideas. As already shown in chapter two, this involves making the links between the things that can be seen and measured and the ideas about what goes on. So far, I had concentrated more on the first domain. I decided to change the emphasis to showing the links to second domain, the domain of ideas.

Week 5 10th February 2005

Following on from the discussions of week four, it was agreed to change the emphasis from investigations to linking the theory to practice. This involved the students carrying out some of the set exercises and obtaining results. The emphasis would now be to hold discussions with the groups on the interpretation of the results. The discussions would then be used to reinforce the links between the theory and what had been observed during the exercise.

Because the students had voiced their concerns over the process being used, it was decided to record a small focus group to capture the feelings of the group. These feelings could then be used in comparison to the interviews I intended to conduct at the end of the term.

In the electronics lab, I provided a revision session for the amplifier and emphasised some of the main properties of the amplifier. We worked through some examples of exam questions. The old problem of being easily distracted continued. During the break time between the two labs, I recorded the discussions of a focus group, with four students, about the process we were using. It was difficult to get volunteers for the focus group. There appeared to be a strong reluctance to take part in the activity, especially as it was during the break time. However, four students did eventually volunteer to discuss their feelings on the process we had used so far.

4.7 Analysis of Focus Group

From the discussions in the focus group, it emerged that the students found it difficult to use the process of finding information. They preferred instead to be given most, or all, of the information and then carry out the exercise. The comment from student number 1 in the focus group was: "*I hadn't a clue of what we were doing*". The others agreed with this. The students felt lost and unable to see what they had to do. The relevance of what they were doing was important to them. They believed that a lot of what they were doing had no relevance to their normal work. Student 3 expressed it as: "*Well it would help you, if you were doing it, you would be more interested in it, it's worth it like*". The same student did not see the relevance of most of the electronics: "*Regarding the electronics and all, you wouldn't really, you know what I mean. So the little bit of knowledge you need out in the field, you'd know*". Student 1 also found the electronics difficult to understand and to relate to: "*...but as far as the components go I really haven't really got a breeze, you know what I mean. If only someone here says why you are doing it*". The students do not use any of the electronics directly as part of their normal work. The measurements lab had more relevance for the students. Trying to relate the theory to the exercises also caused problems. The connecting of circuits did not cause any major problems but understanding what the circuit was doing did cause problems. Student 3 expressed it as "*Yeah, alright at connecting up circuits but graphing some of the stuff, you know what I mean, just getting the graph of them and that you need to state, say what its doing and all that, but you still don't understand it, you just know what you told us. It does this but, you know what I mean*". The linking of the theory to the practice was an important issue to the students. What appeared to compound the problem was the fact that it was about eighteen months in-between the phase four and phase six courses. Student 1 expressed this, as: "*You're not at it every day so you wouldn't really know a lot. All the stuff you learned a year and a half ago, it's all gone out of your head*". This was very relevant as the phase four topics lead into phase six topics, so any long gaps in between would cause problems.

Having recorded the focus group, the measurements lab followed afterwards. As the lab was delayed slightly by holding the focus group, it seemed to break the normal routine and the groups seemed more unsettled than usual. The focus of the session was to examine two common tests carried out on transformers. Before these could be carried out, I had to explain how several of the instruments had to be connected. One instrument, the wattmeter, seemed to cause a few problems. A reading could not be taken directly, it had to be calculated. It took a little time before the students were confident with the readings. I then explained the reasons for the tests and their relevance to questions that appear on the exam papers. Once again, anything that was directly relevant to exams held their attention.

4.8 Action Research Cycle Two

Week 6   17th February 2005

For the electronics session, I used a Triac circuit, a device for controlling the amount of power supplied to a load. I explained the theory for the operation of the circuit. I used a demonstration set for this purpose. All the components are accessible and the output can be seen quite clearly on the oscilloscope. I then asked them about the triggering of the Triac and to record the important point of what we were discussing. I then asked to predict what would happen if I made certain changes to the circuit and why they believed these things would happen. There were many different views and some of them changed their minds after listening to other students' views on what they thought would happen. I then made the changes, one at a time, and asked them to justify why it happened. The students remained interested in the topic as long as I kept asking questions and trying to drag answers out of them. If I stopped, then the talking began. They were easily distracted. On the feedback sheet, there were two comments. The first indicated that the student needed help wiring up the circuit. The second suggested that I write more about what I was discussing in the lab. The positive feeing value was 12.

In the measurements lab, the groups followed on from what we had started the previous week. Two groups of four carried out one of the transformer tests and the other two groups carried out the second test. All the groups had detailed instructions and diagrams. After a little initial confusion on what they were trying to achieve, the groups carried out the exercises and obtained results. I then examined in detail the results they had obtained and explained how these related to the theory of transformers. The idea of recording anything during a discussion does not come naturally to the students. I had to emphasise the need to record important points. We then answered some exam questions from past papers to show how the theory is used. There were several questions on the exercise sheet for the students to attempt but, again, they did not attempt these unless specifically told to do so. One of the comments I wrote for the session was "*Progress is being made but I cannot see any significant difference to the usual outcome of the labs, not yet*!". There were no comments on the feedback sheets. The positive feeling value was 12.

Week 7 24th February 2005

For this electronics session, I had set up a demonstration for a Unijunction Transistor. The class had covered the theory for this already so it should have been a matter of confirming that what they had been told could be observed in practice. The circuit was connected to the supply and then I revised the main points. I then discussed with them what would happen if certain changes were made to the circuit. The interest level was low. Once I moved onto discussing the types of questions on the exam paper the interest level increased. I wrote in the journal: *"The exam is still the driving force"*. Once again, the level of note taking was poor. I had to stress at certain times that they record certain important points. We then moved on to discussing practical examples of the circuit in everyday pieces of equipment. This was used to show the relevance of the device. On the feedback sheets two comments were made. Both said: "*Waste of time*". The positive feeling value was 11.

For the measurements lab, we started with a discussion on the voltage regulation of the transformer. Because there is only one set of equipment available, that this test can be done on, I used it as a demonstration. I allowed several of the students to connect different measuring instruments to the circuit. Once the circuit was working, we recorded several readings and then drew a graph of the efficiency of the transformer. We then spent some time discussing what the results meant in practice, and how we could make sure the transformer could be used most effectively. While discussing and asking questions the students will respond. Once they have to work on their own, such as drawing graphs, they become easily distracted and wander off the point. The discussions, and showing the relevance of topics, does appear to engage them more than the previous investigations. It is the exam questions that hold their interest the most. I wrote in the journal at the time: "*This seems to be the driving force*". There were no comments on the feedback sheets and the positive feeling value was 7.

Week 8 3rd March 2005

In the electronics lab, we examined the Unijunction transistor again. They were given various components and the circuit diagram and allowed to build the circuit for themselves. They worked in pairs. It can be a difficult circuit to get working. If it did not work first time, the groups seemed to lose interest. Instead of trying to identify the problems, they tended to wait until I looked at the circuit and prompted a few suggestions. Eventually some groups got the circuit working. There were few attempts to sort out problems. At the time, I wrote in the journal: "*Is this course so rigid that we have stifled all attempts at trying anything on their own*". If pushed, the students can achieve what they set out to do but, as I recorded in the journal: "*…why do I really need to push so hard*?" There were no comments on the feedback sheets and the positive feeling value was 6.

In the measurements lab, we discussed the connecting of two transformers in parallel. I asked questions about what items they thought they should check before doing this. After some debate, they agreed on certain checks and we then examined these in detail. This kind of topic can be difficult because it is theoretical. It is unlikely that most of them will ever work on transformers and it is something they realise themselves. After the discussion, they connected two transformers together, and checked various voltages. We then discussed what would happen if they got the connections wrong. We then connected them incorrectly and recorded the voltages again. I emphasised the dangers of getting the connections wrong. We then looked at typical exam questions on the topic. Once again, the level of interest was high. I again asked the class to fill in the feedback sheets as accurately as possible to make the feedback meaningful. There were no comments on the feedback sheet and the positive feeling value was 4.

Week 9 10th March 2005

This was the last lab session before the exams. We used it as a revision session. We worked through quite a few exam questions. I then revised a few of the transistor topics and the associated diagrams. The interest level was high as the exams were just a week away. Today was also the day for holding the individual interviews. These had to be held in the break time between the two lab sessions, as the volunteers were reluctant to hold them during their lunch break. The session ended a little earlier than usual to allow the interviews to be recorded.

The measurements lab, after the interviews, was run along the lines of a tutorial class. I explained most of the main points of the transformer theory again. We used many examples of exam questions. The level of interest was, again, high. It was the last chance before the exams to revise anything about which they were unsure. Many of the students asked questions about other related topics, not just the measurements. If I had this same level of interest for the whole nine weeks, I would have been very satisfied. The session finished and the students expressed the opinion that they were satisfied with what we had accomplished.

4.9 Analysis of Individual Interviews

The key points of the interviews are shown below.

Student number one believed the purpose of the labs was to know how to do something if it came up in a work situation and to link the theory to practice. He found: "… *the practical aspect better than the theoretical*". The topics covered did not seem relevant to work situations, however. He described it as: "*I suppose we learned how to do what we were doing, but as far as doing stuff outside of work, outside of here, it wouldn't come in, you wouldn't use it*". Relevance to work has come across as an important consideration. He did not like the investigations that were used for the first four weeks and said: "*It didn't go too well, that part of it*". He felt there was very little teamwork going on. He preferred the discussions after the experiments and felt he understood more from this method. This was described as: "*People started to get a bit more interested because they actually knew, had some idea of what was going on so*". Overall he was 'happy' with the labs.

Student number two believed the purpose of the labs was: "*Basically just to put the theory into practice to see how it works. Trying to make it simpler for people to understand*". He felt he had not learned a lot from the methods used in the lab. He preferred a more tutorial type class and discussions rather than the investigations. More structure would have been appreciated. The groups were too big with four people because not everyone got the opportunity to connect things up. He described it as: "*More from what you were just saying or from what someone else was saying, not from actually doing the bits and pieces, because if you are working with four people, usually you find that some, one person takes over, so they get more from the actual exercise than I would. I wouldn't be one of those people that would sit there and start grabbing things*". Doing the exercises followed by discussions was better: "… *because if you got it wrong you knew exactly where you went wrong, basically, and it's a nice basis to talk about it and then you're able to say exactly, but I got this, so why, and, eh, you basically learn by your mistakes*". He would have preferred smaller groups. He found that the problem with groups of four was: "*Usually you have one or two kinds of strong opinions in the group and they kinda go off and leave the two other lads to sit back and just take down what they are after doing, so it's not too beneficial for the two lads who* *are quiet"*. He found the labs difficult at first but believed that they were beneficial later on.

Student number three believed the purpose of the labs was to show how the theory works in practice. He felt the topics had little relevance to his normal work activity. When asked if he came across any of the topics as part of his work he replied: "*No, definitely not. The same with the little electronics board and all that, like, you wouldn't never be touching something like that at work*". Being able to see what occurs in the circuits by using instruments, such as the oscilloscope, was important. He said of one particular topic: "*We done that in the class, like, but so fast that we didn't get to grasp any of it, you know like that, but you see it on the oscilloscope and you see it all working, like, it makes that bit more sense like"*. The investigations caused some confusion because he did not know a lot about the topic. He felt the discussions were helpful because he could see the results of the experiment and how they then related to the theory. He disliked the large groups because not everyone got the chance to participate and it led to distractions: " *Probably the way it's in big groups, especially in the measurements lab. Because there's too much talking going on, like you know what I mean"*. Working in pairs would be better. He felt the last measurements session, where it was run as a tutorial, was the most beneficial.

Student number four believed that the labs allowed him to see the theory put into practice in the experiments. He felt he learned by carrying out experiments which reinforced the theory. He said: "*I think it is far easier to learn something that is carried on physically in front of you, you see it actually happening, instead of sometimes, with theory it's different like, being able to see something done in front of you"*. The investigations could be useful when several opinions were being expressed. The discussions were useful also, because of the different opinions again. He expressed it as: "*Yeah, I thought it was good to discuss the results, how you came about these results and how you found them, and what's the best way to go back and find faults. Once again there's different answers coming at you, it's different... people do it different ways, so I found it beneficial alright, yeah*". The labs were beneficial because you could carry out in practice what the theory says. He said he found the labs "*very beneficial*".

4.10 Findings of Examination Results

At the end of the phase six term, the students sat the electrical science and craft theory written examinations. After all the exam scripts had been corrected, the examination results for the research group and their peers were compared, to check if any significant differences could be discerned. The results are shown in Figure 4.30.

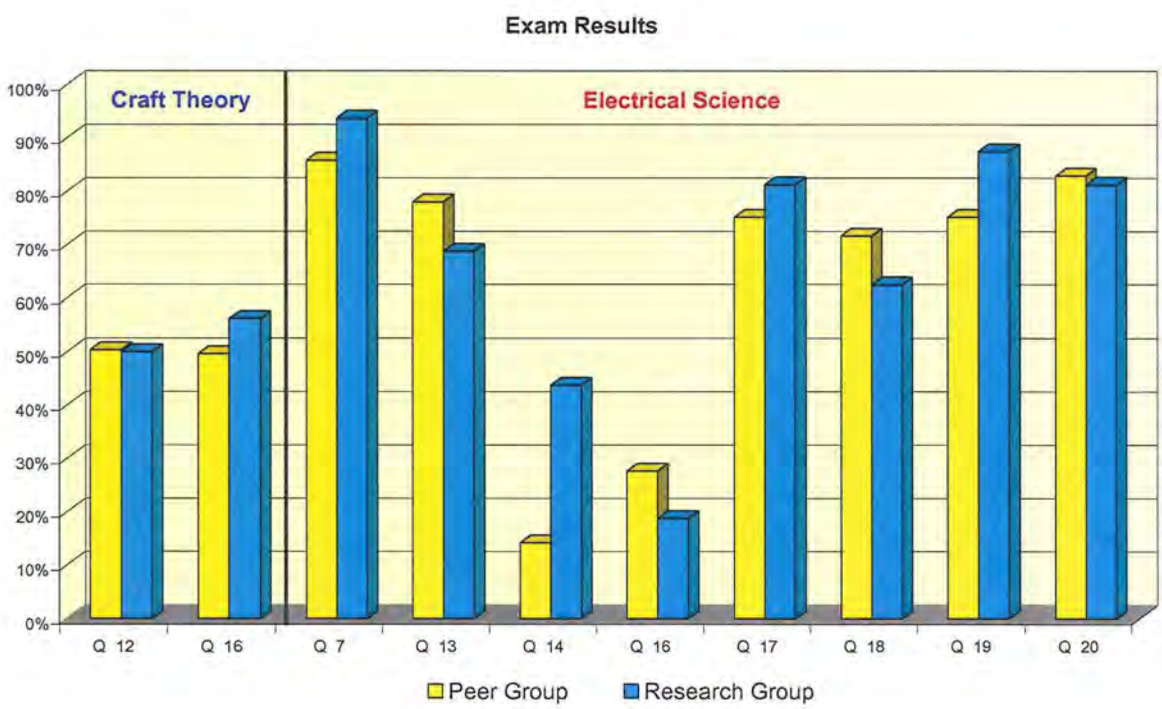

Figure 4.30 Exam results

The research group and control groups could not be compared because they sat different examinations, since the control group were on the previous intake of apprentices. The questions shown on the chart relate to topics that were covered in the measurements and electronics labs. As can be seen, there were two relevant questions on the craft theory paper and eight relevant questions on the electrical science paper. The chart shows the percentage of students who correctly answered that particular question. The results for the research group generally matched those of the peer group. The only significant difference was for question 14, in electrical science, where the research group achieved a score of 44% as compared to 14% for the control group.

4.11 Summary

This chapter has presented all the data collected during this study. This data was collected using several methods. These included a questionnaire to the control group and the research group, the focus group recordings, the individual interview recordings, the reflective research journal, and the lab feedback sheets. The second action research cycle changed significantly from the original intended design. This was due to the findings from the first research cycle, the focus group and, to some extent, the lab feedback sheets. The questionnaire showed the comparison of the control group to the research group over the twenty questions. The next chapter examines the interpretation of these findings and discusses their significance in the delivery of the phase six electronics and measurements labs.

CHAPTER FIVE

Discussion of findings

5.1 Introduction

This chapter discusses the interpretation of the findings of the data collected during this study and that were presented in chapter four. The discussions focus on how the findings contributed to showing if the constructivist approach used for the labs had an impact on the effectiveness of the labs. The discussions use the qualitative and quantitative data collected from the various methods to show the context of the electronics and measurements labs and the effects of the two cycles of the action research. The lack of any evidence of self-directed learning is discussed and how it impacted on this study. The data from the focus group, the individual interviews, and the reflective journal provided strong indications of how the students felt during the two cycles and how my own reflections on the lack of progress in cycle one were used to change the approach used in cycle two.

The objectives for this study were to:

1. Establish the current situation in relation to the effectiveness of the labs
2. Devise methods to collect data to measure changes to lab delivery and operation
3. Increase students' awareness of underlying principles of particular topics while carrying out the related experiments
4. Increase motivation of students in the labs by using a constructivist approach in their delivery
5. Use problems encountered in work situations to generate group discussions and allow students to choose exercises to validate their answers
6. Increase student participation in the labs

7. Justify the continued use of the labs

The discussions will indicate to what extent theses outcomes were achieved. The order of the discussions follow that of the presentation of findings, namely: the questionnaire, the lab feedback sheets, cycle one of the action research, the focus group, cycle two of the action research, the individual interviews, the examination results, and the reflective research journal.

5.2 The Questionnaire

The questionnaire was used mainly to gather data for assessing how the students perceived the lab classes. The first four questions were also used to give a view of a 'typical' phase six electrical apprentice. From the findings, presented in chapter four this typical apprentice would be aged 22 to 25 years, have achieved the Leaving Certificate, have attended an ESB centre for phase four, and would be working mainly on industrial and commercial installations. This profile is significant because the age of electrical apprentices is higher than in some other European countries (Hartkamp and Rutjes, 2001). The minimum age requirement for the electrical apprenticeship is 16 years (FÁS, 2000). This would indicate that the apprentice would be aged at least 20 years when undertaking the phase six course. The survey showed the majority of the control group to be 22 years or over. One of the main reasons for this higher age profile is found in the data for question one (Figure 1) of the questionnaire. This question looked at the highest educational qualification at the start of the apprenticeship. For the control group 78% had achieved the Leaving Certificate at the time of starting the apprenticeship. The minimum entry requirement is Junior Certificate with grade D in five subjects. By achieving the Leaving Certificate, the majority of electrical apprentices are generally up to two years older than the minimum age required. In Ireland the figure for all apprentices who have the Leaving Certificate is 53% (Joint Working Party on Educational Progression for Craftspersons, 2001). The figure for the electrical apprentices is substantially higher than the average figure, as this study shows.

It was seen that 47% of the control group had attended an ESB centre for phase 4. For the research group this figure was 67% (Figure 4.3). There is a substantial difference in the teaching methods used by the ESB centres. The ESB centres tend to use one lecturer for all of one subject. They also tend to study only one subject at a time, and then take the examination and move onto the second subject. In the DIT several lecturers cover different topics for each of the two subjects. Both subjects are covered at the same time, over the duration of the course, and examined at the end of the course. Changing from one format to the other may be confusing. For phase six, most of the apprentices need to adapt to a different system. To succeed they need to possess or develop skills that will enable them to organise the different topic notes into a format that they can use effectively. From experience of many phase six classes, it can take some time to develop these skills but with practice it can be achieved (Cottrell, 1999). For those apprentices who had attended DIT, for phase four, the format is the same as that used for phase six, so the transition to phase six may be more straightforward.

The results of question four show that the majority (54%) of electrical apprentices work on commercial/industrial installations but only 15% work solely on domestic installations. The remaining apprentices work on various combinations of work activities (Figure 4.4). These figures have a strong bearing on how the apprentices see the relevance of what they cover as part of the phase six course. Many of the topics covered as part of the electronics would be useful to apprentices who work on maintenance type activities. The figures for the number of apprentices that carry out any type of maintenance activities accounts for only 15% of those surveyed. Considering the low number of apprentices who worked in maintenance, this would suggest that there was little relevance to their work. There was a very negative response to question 5 from the research group (Figure 4.5). Very few of the research group carried out any type of maintenance work activity so this view was understandable. The main relevance that the students could see about the topics covered in the electronics lab, was the fact that questions would appear on the examination paper. The topics covered in the measurements lab were much more work relevant and this would have accounted for the higher positive feeling for the research group.

The students showed very little interest in topics that they did not deem relevant to them. There are two aspects to the topic of relevance. The first is relevance to work situations and the second is relevance to the examinations at the end of the course. Nearly 50% of the research group agreed that they found the topics covered in the electronics lab interesting. The level of interest was due to the fact that the topics and exercises were relevant to the examinations rather than work situations. This is also borne out by the statements made by the students during the individual interviews (Appendix I). It has been shown several times, in the presentation of findings in chapter four, that the students' level of interest in a topic is strongly related to its appearance on the examination paper; this is not an unusual observation. Other studies have been carried out in the Electrical Services Engineering department with the co-operation of phase four electrical apprentices. The first was on developing the numerical problem solving abilities of the apprentices (Eastwood, 2003) and the second was on the ability of the electrical apprentices to communicate their technical knowledge in an effective manner (Harding, 2003). Both of these studies noted the same difficulty; that of the apprentices being very focused on the immediate goal of passing the end of term examinations to the exclusion of everything else. As has been mentioned previously in chapter two, this can lead to a behaviourist approach to learning. The students want handouts with short, concise notes about the topic and tailored to suit the examination questions. In a constructivist approach, the relevance of topics is important to stimulate the interest of students and keep them motivated (Brooks & Brooks, 1993). With the research group this motivating effect was only evident in relation to topics directly related to exam questions.

With the research group I had gone to great lengths to explain the purposes and the benefits of the labs to the students. The literature regarding practical work had also stressed the importance of making the aims and objectives, of the exercises in the labs, very clear (Wellington, 1998; Psillos & Niedderer, 2002). I had done this at the start of each session during the research cycles. The results for question seven, for the research group were higher than those for the control group but not significantly so. The value of *no opinion* (Figure 4.7) showed that there were still students who were unclear about the purpose of the labs or who simply had no interests in the labs. The research group had a more positive response to question eight than the control group for both the electronics and measurements labs. This was again related to the aims and objectives of the exercises, which I explained at the start of each session. Since it is an important aim of lab work to link theory and the exercises, a high level of understanding of the principles is essential if the link is to be made (Millar, 2002). The figures indicate that the students had a good understanding of the principles.

One of the main principles of constructivism is the social aspect of learning. This is stressed by Tobin and Tippins (1993, p.6) when they state: "*The recognition that knowledge has both individual and social components that cannot be meaningfully separated enables us to construct science learning environments where multiple ways of knowing...are sought and valued*". The interaction of different ideas and theories allows students to see differing perspectives and adds to their level of knowledge. The students worked in pairs in the electronics lab but worked in groups of four in the measurements lab. The reason for the larger groups was that there were not enough sets of larger equipment to allow students to work in pairs. While groups of four allowed for sharing out the work load for setting up the exercise and taking readings, it had the disadvantage of allowing some students to sit back and let others do the work. It also led to a great deal more talking between the students, on topics not related to the exercise. This was commented on by several of the students during the individual interviews (Appendix I). Since I was the facilitator for the groups I had responsibility for keeping the groups motivated and focused on the topics. Despite adopting the practices recommended by Race (1998) for dealing with problem groups, the distractions still persisted. This type of problem did not arise when the students worked in pairs and the students acknowledged that they much preferred to work in pairs rather than larger groups, because they had fewer distractions. This point was also raised by the students in comments made on the questionnaire. The comments made were to allow students to work in pairs and to have sufficient equipment in the labs to allow this.

The students were correct when they said there was a lack of equipment in the measurements lab. Since it tends to use larger equipment and many more measuring instruments, it obviously costs much more to provide the facility for the exercises. The other constraint in the measurements lab is space. There physically is not enough room to provide eight sets of equipment for all the different exercises. This is a resource problem and one that is the source of much debate amongst academic staff in the faculty. It was not one that I could control directly and it had to be accepted in the short term that there were not going to be eight sets available for the students. The general opinion of the students was that they preferred working in pairs and liked to discuss topics as they worked through the exercises. The results for question 9 (Figure 4.9) showed that the research group had a higher value of *agree* than the control group, despite the drawbacks highlighted.

The open ended questions were included in the questionnaire to allow the students to express their likes, and dislikes, of the labs and then to write any other comments about the labs. The results for the control group were shown separately from those of the research group. This was because the research group made very few comments on the questionnaire and to show these as a percentage compared to the control group would give a distorted view of the comments.

For the control group, question 17 initially yielded 32 different categories and these were then analysed to give seven main themes, as already described in chapter four. The *working with components, building circuits* category was the most liked feature of both the electronics and measurements labs. These are practical skills and the type that the students can use as part of normal work. The type of circuits that are used in the measurements and electronics labs will not be identical to those encountered in normal work activity but the same skills are used. These include the ability to read circuit diagrams, connect measuring instruments safely, and take accurate measurements.

These are the type of activities that are listed in the phase six syllabus for carrying out practical work. The students carry out these activities and can usually attain a proficient level. Question 12 shows that approximately 50% of the control group agreed that connecting up instruments was straightforward for the electronics and measurements labs (Figure 4.12). The figure for the research group is much higher at approximately 75%. These figures are significant because one of the main aims of practical work is to get students to connect circuits and take measurements (Millar, 2002; Psillos & Niedderer, 2002). While the students do make mistakes when connecting circuits, they usually find the problems quickly when you question them about why they make certain connections. This observation was recorded in the research journal for week 4 of cycle one. Connecting circuits is one of their main activities as apprentices and is an essential part of their work practices. The students would not have seen some of the equipment in the labs before but they generally made good efforts at connecting up circuits from circuit diagrams.

The next highest category was *linking theory to practice*. As has already been stated, the linking of the theory to the exercises is one of the main aims of practical work. The building of circuits requires practical skills and this is related to question 14. The linking of theory to practice requires cognitive skills, such as problem solving or decision making. There must be a conscious decision to make the link between the two areas by actively engaging with the topic. Not all the students were willing to make this decision. Question 14 showed that the research group had a better grasp of the links between the theory and the exercises, than the control group (Figure 4.14). This is also linked to question 8 (Figure 4.8), understanding the principles of the exercises. In cycle one I had attempted to establish these links by using investigations with the students. As part of the investigations the students needed to think about possible solutions to the problems and then use one or more of the available exercises to prove, or disprove, what they believed to be a viable solution. By doing this it was hoped to allow the students to construct their own links between the theory and the exercises. This proved to be too ambitious in the available timescale, so in cycle two the emphasis changed to carrying out the set exercises and then holding group discussions on the results of the exercises.

By looking at the interpretations of the results, and how these corresponded to the theory, it was then hoped to achieve the aim of linking the two areas. This second approach proved to be more effective. The comments made in the individual interviews provide more evidence to this effect. Question 16 asked if the students felt they had learned from carrying out the experiments. The results to this question show that the feelings of the control group were broadly similar for both the electronics and the measurements labs (Figure 4.16). A small majority felt they had learned but there was still a sizable minority who felt they had not. It was precisely because of this level of feeling about not learning in the labs that I initiated this study. The research group shows a larger majority in favour but the numbers disagreeing are still significant. The figures for the research group were disappointing because having gone through two cycles of the action research, I had hoped that the students would have gained a greater understanding of the importance of carrying out practical work. The figures suggest that they learned more from the measurements lab than they did from the electronics lab. This may be related to the relevance of the topics covered in the labs. As has already been shown, the relevance of a topic was very important to the students. The research group had achieved a significant step towards realising one of the aims of the study; that of linking the theory and practical aspects of lab work.

The next category of *nothing* showed that there was a sizable percentage of students who did not like anything about the electronics or measurements labs. This again shows that there was a failure to engage with the labs and that more needed to be done to resolve this situation. The *lab environment* referred to the physical layout and condition of the labs. The comments made about the layout of the labs referred to the layout of the benches and the space in the labs. In the measurements lab there is the particular problem of not being able to see some of the students clearly if the lecturer is stood at the white board because of the height of one of the centre benches, so the students had to move positions on some occasions. This added to the difficulty of maintaining their attention if I could not see the students clearly. Approximately 30% of the control group, for both the electronics and measurements labs, disagreed that the layout of the labs was helpful for conducting exercises (Figure 4.11). The research group were more positive towards the layout than the control group. This is probably due to the fact that the research students tended to work in their own groups more than in the case of the control group, rather than looking at the white board. In general, the students were not impressed by the facilities offered in the labs but they did like the comfortable chairs. Again, the condition of the lab is a resource issue and one that is frequently highlighted. The *distractions* category was a result of students' comments about activities in the lab that had nothing to do with lab activities. This again shows that a number of students had no interest in the labs. Other students found aspects of the lab *useful* for the process of learning. The category of *tutorial* included discussing topics on the course but not directly related to the exercises. The last session of research cycle two was run as a tutorial class, which the group found very helpful for revision for the exams, and this is probably why the value for the research group (figure 4.18) is higher than that for the control group.

When asked what they disliked most in the labs (Question 18), the students were mainly critical of the teaching methods and equipment, and many felt the labs were a waste of time. The results are shown in Figure 4.19. These issues were also raised as part of questions 19 and 20. It is clear that many of the students were dissatisfied with some aspects of the labs. While there are some resource problems with the labs, these can be addressed over time and dealt with effectively. Plans are already in place for alterations and repairs to the labs and these are expected to be carried out before the start of the new academic year. The teaching methods are an issue that can, and must, be addressed by the members of our own department. This study is one small step in an attempt to highlight the problem and attempt some realistic solutions to the ongoing problem of the teacher centred approach. The students deserve high standards and all of us who teach in these labs have a commitment to achieving them.

5.3 The Lab Feedback Sheets

This part of the data gathering process is one which failed to generate the clear evidence that I hoped would show the students' feelings towards the lab work. The intention had been to show the changes in the students' attitudes to, and their level of confidence in, the labs as the research progressed through the cycles. This did not materialise in practice. The research group did not take the opportunity to record their comments on the feedback sheets and as the weeks progressed the number of sheets returned at the end of each class diminished. Of those who did fill in the sheet, it became obvious that they were not filling out the sheets carefully. I had deliberately included a line of boxes with no question attached. Some of these boxes were regularly ticked showing that care was not being exercised in completing the sheets. The level of *no opinion* options was also high. In general, the sheets showed that the level of engagement with the labs varied over the weeks. I had tried to ask questions that would allow me to judge how the students felt about each lab. With my lack of experience in writing questionnaires, I probably made the questions too confusing for them to answer simply. Having to fill one out for each lab probably also made it repetitive. This is part of the learning process for me. The process of action research is reflecting on what has happened and making judgements about what changes are necessary to improve the situation. Knowing what I do now, I would have asked different questions.

With so few comments provided by the research group about the labs, it was difficult to get a reliable feeling of how they regarded the labs. Even when they were given the same questionnaire that the control group filled out, only four students included comments in the open questions. There seemed to be a reluctance to provide any kind of feedback for the research. Even when holding the focus and individual interviews it was difficult to get volunteers. When I did eventually get the volunteers, they would only do the interviews during normal class time. I can understand their reluctance to participate actively in the research. They viewed it as something that was of benefit to me but they could not see any benefit to themselves, as they would be leaving the college in a few weeks time. I do not believe that I had convinced them of the possible benefits to themselves. If they had been able to perceive the possible benefits, they may have been willing to provide more effective feedback. If I were to repeat the research then I would change the questions on the feedback sheet to simple questions with a 'yes' or 'no' answer with a provision for comments if the answer was 'no'.

5.4 Action Research Cycle One

Cycle one used the approach of giving the students problems to work on and to find a viable solution. The idea was to allow the students to come up with theories or ideas about possible solutions to the problems and then use one or more of the exercises in the lab to prove, or disprove, the suggested solution. This process was used for five weeks, making up cycle one. This process did not proceed as planned as it was different to the way the students normally carried out lab work. The standard method was to carry out an exercise from an instruction sheet and then write up the experiment using the headings of Title, Apparatus, Method, Observation, Results, and Conclusion. By allowing the students to move away from this structure, it was hoped that they would work as a group and pool their existing knowledge of the topic. They had access to their own notes, textbooks, handouts, and the rules for electrical installations. Information was available but not all contained in a concise handout. This was not what the students expected or, as this study shows, wanted. The results for question 13 (Figure 4.13) show that the research group were generally less satisfied with the instructions provided in the lab than the control group.

On week one I had discussed this approach with the students and possible ways they could go about solving the problems. Over the five weeks of the cycle the results were disappointing. Instead of using the opportunity to discuss the topics, the students tended to discuss everything but the topic, unless I was with the group and asking questions. Once I questioned the group they were able to provide answers that would lead them to a possible solution. In a constructivist classroom: "*...the teacher searches for students' understanding of concepts, and then structures opportunities for students to refine or revise these understandings by posing contradictions, preparing new information, asking questions, encouraging research, and/or engaging students in inquiries designed to challenge current concepts*" (Brooks and Brooks, 1993 p.ix). By posing problems, I had hoped to enable the students to look at their understandings of concepts and apply them to particular problems to see if their understandings were viable in the particular contexts. This, however, did not happen. By the end of week four the students were unhappy with the format and did not wish to continue with it. The approach I was using clearly did not suit the context of the apprentices in the labs. By removing the formal structure, I had taken away the familiar framework in which the students normally work. They felt lost and out of their depth and this was confirmed by the comments made during the focus group discussions (Appendix K) and the individual interviews (Appendix I). I had badly misjudged the ability of the students to change to a new learning style in a short space of time. This reluctance to try new learning styles is commented on by Sneyd (2005, p.148) in relation to apprentices in Ireland, when he states: "*Having been used to teacher centred methods they may be insecure and be reluctant to 'dip their toe'*. This was also a reflection of my own ability to support this type of learning. It was the first time I had tried this type of approach and I had underestimated the time and effort required to implement it. Bruner (1977, p.xiv) commenting on the use of problem solving for learning stated: "*...there is a vast amount of skilled activity required of a "teacher" to get a learner to discover on his own...*". I had to reflect carefully on what I was expecting from the students. I still needed to get the students to link the theory to the practice rather than just carry out exercises for the sake of connecting circuits. Another possible way forward, on reflection, was to use discussions after the exercises to make these links, as part of the action research cycle. This was the approach that I then used for cycle two.

Cycle one had shown that the initial constructivist strategy I had chosen was not suitable for the context of the apprentices in the labs. The strategy needed a good degree of commitment and self-directed learning from the students. Self-directed learning is what Wisker (2001) describes as fostering critical questioning and reflection. They were committed to achieving their short term goal of success in the end of course examinations, but the learning styles used did not include a great deal of self-directed learning. The available literature on studies carried out with apprentices show that, in general, apprentices exhibit little in the way of self-directed learning. Smith (2003, p.369) commenting on the learning styles of vocational education and training (VET) learners in Australia, including apprentices, states that: "... *these learners are typically not self-directed, but that they are more comfortable in instructor led environments where there is a clear structure in the learning programmes undertaken and clear guidance for going about that learning".* He goes on to state that other literature identifies a low level of the metacognitive skills needed to develop self-directed learning. Referring specifically to apprentices he states: "*...apprentices are dependent learners who like to work within an externally provided structure*" (Smith, 2003, p.378). This has been shown to be the case with the research group of apprentices.

In the context of apprentices in Ireland, a survey of apprentices from different trades and three different third level institutes, found that the level of independent learning to be low (Sneyd, 2005). The survey also showed a strong correlation between independent learning and examination success. In a study carried out in the Electrical Services Engineering department with phase four apprentices (Byrne, 2002), using self-directed online learning resources, found that it took extra efforts on the researcher's part to encourage students to access the online resource and that the participation of the students varied greatly. Other studies in the department (Eastwood, 2003 and Harding, 2003), as part of a collaborative study into communication and numeracy skills, also found strong evidence of the students being purely exam focused and unwilling to go outside the normal classroom structure. It is clear that I failed to grasp how difficult it would be for the students to change from the standard learning format to that of using a constructivist approach. This study has shown little evidence of self-directed learning. The studies by Byrne (2002), Harding (2003), and Eastwood (2003) involved apprentices from phase four of the Standards Based Apprenticeship scheme. The apprentices involved were from different groups, yet they typically displayed little motivation to go outside the normal learning methods of the phase four or phase six courses. The phase four and phase six courses share this one common factor. It is probable that the teacher centred methods employed on the courses are preventing students from availing of different learning styles. It would require further investigations to provide more evidence to support this theory. Certainly in this study I am left with the strong feeling that this is the case.

As I have commented several times in the research journal for this study, the students are very focused on the aim of passing the phase six exam and moving on to the final phase seven of the apprenticeship. Anything that is not directly related to the exams is viewed as irrelevant. The notion of searching for information also seems to be a new concept to the students. The expectation appears to be that all the answers are in the distributed handouts and that everything they need will be given to them, without any effort on their part to identify what is required. This is a very strong behaviourist tradition, as described by Thorndike (1926) and Skinner (1968). We have conditioned our students to behave in this manner by the way we structure the course delivery. We expect the students to attend classes from 9.00 to 5.00 each day continuously for the ten week duration of the course. There is no self-study time built into this system and this does not foster any degree of self-directed learning. This is also stressed by Sneyd (2005, p.147) when commenting on the learning style of apprentices. We would not find this acceptable for a full time course, yet we accept it as part of the apprentice course. The main difference is that we regard the apprentice courses as part of a training programme.

Training courses are viewed somewhat differently to fulltime courses. General education according to Moodie (2002 p.250), using the international classifications of education by UNESCO (1977): "*…is mainly designed to lead participants to a deeper understanding of a subject or group of subjects, and 'vocational or technical education', which is mainly designed to lead participants to acquire the practical skills , know how, or trade or class of occupations or trades*". The emphasis is placed on practical skills. Moodie (2002, p.260) states: "*Thus, one may consider vocational education and training to be the development and application of knowledge and skills for middle level occupations needed by society from time to time*". The educational level at which apprentice courses are placed varies widely between different countries. It is generally regarded as being at upper secondary or lower third level. It seems problematic to categorise precisely. *"It is different in different jurisdictions at any one time, and changes within many jurisdictions over time"* (Moodie, 2002 p.257). In the Irish context the National Craft Certificate, for apprentices who successfully complete their apprenticeship, is awarded at level 6 by FETAC, on a scale of ten. The Leaving Certificate, the exit examination for the majority of Ireland's secondary school students, is placed at level 5 on the same scale.

It is clear that there is an overlap between general education and vocational education in the area of apprenticeship. The learning of practical skills is usually accomplished by cycles of observing and practicing. Over time the students become proficient in the skills. The theory aspects of the course require the use of cognitive skills, the same as used by students of full time courses. There has to be a balance between the two types of learning that will allow apprentices to gain knowledge in a meaningful way.

5.5 Focus Group

The views expressed by the four students in the focus group were in line with the views expressed by the majority of students when I spoke to them as a group at the end of week four. It was because of the depth of feeling expressed during this discussion, about the investigations, that it was decided to record a focus group. The main themes that emerged from the focus group discussions, at the end of cycle one, were the importance of relevance to work, linking of the theory to the exercises, and the confusion and dislike of the investigations.

The importance of relevance to the students has been raised already by question five in the questionnaire. The relevance of a topic to work situations had a motivating effect on the students. It allowed the students to relate to it and build on the knowledge they already had about the topic. This is also stressed by Ryan (1998, p. 291) in relation to apprentices when he states: *"It is often claimed that a curriculum which contextualises knowledge to the workplace increases the scope for learning as well as student* *motivation, relative their counterparts under a purely school-based approach".* The concept of 'cognitive apprenticeship' (Brown *et al*, 1989) can be applied to the type of learning that uses authentic practices to enable students to learn. The teacher first introduces the concepts of a topic and then supports the students as they attempt to put these concepts into practice. The teacher then allows the students to work without the support. These are the modelling, coaching and fading stages of the learning. This concept fits in well with the constructivist approach. The more authentic and relevant the topics were for the research students the more they were interested. From the point of view of the electronics lab, not many of the topics covered could be applied to work situations. The measurements lab scored stronger on this point. As already mentioned, the only other relevance the students saw for topics was if it appeared on the exam paper.

The students expressed the view that the linking of the theory to the exercises was important and it allowed them to understand the working of the individual devices. This is one of the main aims of the labs. The students appeared to understand the reasons for the labs but still had difficulties with getting anything useful from them. The approach of using investigations for attempting to make the link between the two different domains, as explained in chapter two, was not effective. The students felt lost and confused and wanted the format used in the lab changed. The format of using investigations was changed to that of using in-depth group discussions about the results of the exercises.

5.6 Action Research Cycle Two

The approach used in this cycle was to carry out an exercise on a particular topic and then use questioning and discussions to build the links between the data derived from the experiment and the theory underpinning the exercise. This format was much closer to the formal structure that the students were used to and, it became clear that they felt more comfortable with it. While the level of engagement was not as high as I was expecting, the students were no longer confused by the approach I was using. The level of discussions over the four weeks of this cycle varied greatly. At times the interest level was high and at other times it was so low it was difficult to obtain answers to questions. Most of the students participated to some degree in the discussions. A minority of the students, however, did not participate actively in the discussions and would only engage briefly with the topic if directly questioned.

One of the main reasons for using a constructivist approach was to increase the level of participation of the students in the labs. Even with this approach I was failing to get all the students involved. When I spoke to these students informally they said that they wanted to concentrate on the exam topics and that they would be fine when they came to sitting the exams. These particular students were in no way disruptive to the running of the classes but it was disheartening to find that I had still not managed to instil any enthusiasm for the lab work. Driscoll (1994) comments on the demands that constructivist learning goals and instruction can have on both students and teachers, and the need for teachers to coach those who lack certain skills and persuade those who are unwilling or unmotivated to engage in instruction. She comments that the best way of achieving this is an open question and that there is no easy solution to the problem. Every context is different and it is part of my function, as the facilitator of learning for the students, to investigate ways of dealing with problems. It can be seen that even the constructivist approach does not solve all problems immediately.

Using the method of discussions also led to another problem. Unless specifically told to do so, the students did not write anything down as we discussed the particular topics. This meant that we had to set time aside to formally write down the main points of the discussions as we progressed. The skill of note taking is not one that the students had developed. Again this is due to the structure of the phase four and phase six courses. Handouts are given for most topics and if extra information is required, the students are told when and where it should be added to the handouts. Again this is an area where I can improve my own practice and introduce changes such as, making handouts more interactive and engaging students with the material as part of the labs (Psillos & Niedderer, 2002).

The last session of cycle two was used to revise all the topics covered in the labs over the previous eight weeks. The level of interest was high because it was once again exam focused. One of the comments from the individual interviews (Appendix I) was that the students thought that this was the best class since the start of the course. While I was pleased that the students felt they had gained a great deal from the class, it also meant that the previous classes could have achieved more. There was certainly a great deal to reflect on.

5.7 Individual Interviews

The individual interviews (Appendix I) were used to assess how the students felt about their learning over the two cycles of the action research. They showed that the investigation type problems were not liked by the students and they much preferred the discussions after the exercises. The lack of relevance of the topics to their normal work had a large impact in their interest level in the topics. The level of interest was determined more by the relevance of the topic towards the exams. The reasons for conducting lab work appeared to be well understood by the students. The efforts of explaining the purpose of each of the exercises at the start of each lab class, informing the students of the link between the theory and the practice, allowed them to put the exercises into context. This part of the approach for improving the labs had an impact on the students' ability to see why the exercises were included in the syllabus.

The larger groups in the measurements lab were not liked. Each of the students commented on the size of the groups. The problem of the larger groups is one that the department should be able to solve, at least with some of the exercises, by funding extra equipment in the labs. Working in pairs is what the students prefer. The larger groups led to many more distractions and consequently less engagement with the topics. This is one area where adopting good practices for group work (Linn & Burbules, 1993) can make a significant contribution to better learning.

All the students said they had learned from the labs, some more than others. The initial investigations had not been effective but the discussions were liked by the students. How the students learn depends on the student's own learning style. Creating an environment in which students could be facilitated to build on their own knowledge and gain new understandings is the aim of improving the effectiveness of the labs.

5.8 Exam Results

The results shown in Figure 4.30 indicate that there was generally no significant difference between the peer group and the research group. Only on question 14 did the research group perform better than the peer group. Even if the research group had performed much better than the peer group, there would be no direct evidence showing that this improvement was due to any changes in the lab work. All the topics are covered as part of the theory classes and the questions could have been answered even if no labwork had been carried out. The results show that the research group performed to the same level as their peers. Because of the lack of assessment in the labs I could only use my judgement of the students' performance by observing them as they carry out the exercises. This can be very subjective and can only be used to give an indication of the students' performance. The feedback sheets were intended to give a clearer indication of the students' own feelings on their performance but this did not occur.

5.9 The Research Journal

This was used to keep track of events and to record impressions, feelings, and observations by myself as researcher/practitioner, as they occurred in the labs. From reading through the journal again it is clear that the use of investigations did not stimulate the students to embrace the concepts of investigations. During cycle one the impressions I recorded were of the students feeling lost about how to go about solving the problems and waiting for direction from me. I recorded several times that there was no evidence of self-directed learning. The same was true, to a lesser extent, for cycle two even though the teaching methods were different. What did change was how the students felt about the labs. From their point of view everything was back to the normal process and the group appeared more relaxed about getting the exercises covered. The record of events showed the students progressing from total confusion to one of relief to be back on familiar ground. At the same time my own feelings changed from hope and anticipation to ones of frustration and resignation. Frustration from the point of view that I was still unable to provide the motivation to engage more in the labs, and resignation to the fact that the students were reverting back to the more usual format of the labs. For cycle two the students carried out the experiments but the discussions after the experiments were the important part. Even though I had to continuously remind them to record the information as we discussed the results, I felt that they were making the links between the theory and practice. The students provided answers to the questioning, which showed that they had knowledge of the topic and could relate the results to the theory. Learning was taking place but it was not a smooth flowing process. Instead of me facilitating the learning process I found I was driving the students forward. On reflecting on what was occurring I had to accept that I needed to refrain from doing this.

5.10 Summary

The methods used to collect the data were the phase six questionnaire, focus group discussions, individual interviews, lab feedback sheets, exam results and the reflective research journal. The questionnaire provided information about the profile of a typical phase six apprentice. It also provided information for comparing the control group to the research group, in relation to how they viewed the two labs. It was effective in showing the impact of the changes made to the labs. Overall the research group showed a more positive feeling towards most aspects of the labs than the control group. This was encouraging to see despite the problems encountered during cycle one of the action research.

The focus group discussions, the individual interviews, the research journal, and the open ended questions on both the questionnaire and lab feedback sheets, provided the qualitative data for this study. This data was used to provide evidence of how the groups felt about the changes to the running of the labs. The evidence shows there was a very definite focus on end of term exams. There was little evidence to show any degree of self-directed learning. These two characteristics together made the introduction of investigations into problems a difficult process for the students to engage in. The level of engagement with this approach was low and led to a lack of progress and feelings of confusion for the students. In the context of the phase six group in the two labs it was shown that the introduction of the new concept of investigations was not a viable approach. After reflecting on the students' comments, both in class and from the focus group, the emphasis was changed to using post exercise discussions, to place the results obtained from the exercises into context and to relate them to the theory. This approach proved to be more effective.

While cycle two was more effective than cycle one, it still failed to engage the interest of all the students in the group. There are still issues of relevance and resources that need to be resolved. The students went through stages of adaptation and learning during this study and I too had to adapt and learn from the process. Being inexperienced in research at the start of this study, I had made basic assumptions about how the students could learn. I have learned from the process that the students will only be open to methods of acquiring knowledge that suit their particular context. It is recognising how to suit the learning approach to the context that I struggled with, but I am now more aware of the problems involved and can strive to overcome these.

The issue of validity is important to any study and Cohen *et al* (2000) describe in detail many different methods for checking validity. For this study I have considered the *descriptive validity*, the factual accuracy of the account, carefully. I have recounted the events and feelings as they occurred and have used them to record the findings, and from these findings I have drawn the conclusions. I have tried to be as honest and open as any researcher can be, who is involved in action research. I can claim that the findings are valid for the context in which the study was carried out and that the findings may be an indication of what could be achieved in other areas, such as the classroom. To show this, however, further studies would have to be carried out.

The experience of introducing change was not an easy one. Block (1987) quoted in Fullan (1993, p.17) states that: "*Almost every important learning experience we have ever had has been stressful. Those issues that create stress for us give us clues about the uncooked seeds within us that need attention*". I have experienced what can happen when change is introduced and its consequences. This is something that the students have also experienced and now I am more aware of how they must feel when the familiar structures within which they work are removed. This is an important point that I will consider for any future research.

CHAPTER SIX

Conclusions and Recommendations

6.1 Introduction

This chapter describes the conclusions and recommendations of this study, which are derived from the discussions on the interpretation of the findings in chapter five. The aims and objectives for this study were set out in chapter one and it is on the achievement of these aims and objectives that a judgement is made on the effectiveness of the study. The main conclusions are stated and are justified by the evidence presented. The recommendations outlined are those which could have a beneficial effect on the students, learning within our department and the apprenticeship scheme in general.

6.2 Outcomes

The conclusions are based on the discussions of the findings. The main discussions centred on the findings of the attempts to use a constructivist approach in the running of the phase six electronics and measurements labs. The first objective of establishing the existing situation in the labs was achieved by using the data collected from the phase six questionnaire to show that there was some dissatisfaction with the delivery methods of the labs. The main reasons for this dissatisfaction have been shown to be the teaching methods involved and the lack of equipment in the measurements lab, resulting in larger size groups. The second outcome of devising methods of data collection was also achieved. The methods of using the questionnaire, focus groups, reflective research journal, and individual interviews were successful in generating clear evidence for reaching conclusions. The methods of using lab feedback sheets and exams results were less successful. The lab feedback sheets provided some useful data for judging the positive feeling of the research group as the cycles progressed but, could have been more effective if the questions had been worded differently and if the students had been more open with comments about the labs. The comparison of the exam results for the research group against their peers showed that they performed as well as their peers but showed no significant improvement, but it did show that the research had no negative impact on their exam performance. The third outcome of increasing awareness of the principles of the exercises is shown by the results of question eight on the questionnaire. It showed that the research group did have a greater understanding of the principles of the exercises for the measurements lab but not significantly so for the electronics. The results of the interviews also provided evidence to back this up. The discussion type approach that was used in cycle two also showed that the students did have an understanding of the principles.

The fourth outcome of increased motivation was not so clear. During cycle one the motivation levels were low but in cycle two motivation was much greater, however it is difficult to quantify how much better this would be than if the standard approach was used. Outcome five was also problematic in that the investigations that were implemented were not effective in the phase six context, as the evidence from the focus group and individual interviews showed. Outcome six, that of increasing student participation, was not achieved for cycle one but was achieved for cycle two. The last outcome of continuing the use of the labs is quite clear. Despite the dissatisfaction with some aspects of the labs, the majority of students still viewed the labs as being beneficial and the majority of students still felt they had learned from them. The challenge is to improve this learning. The recommendations outlined in this chapter are made with the intention of achieving this improvement.

6.3 Main Conclusions

The main aim of this study was to see if a constructivist approach could improve the effectiveness of the two labs. The main conclusion is that the effectiveness can be improved if a suitable approach is used. A suitable approach is one that the apprentices can relate to and engage in. Using an approach that relies heavily on self-directed learning is not a suitable approach in the context of the phase six labs. The approach used in cycle one was too far removed from the normal teacher centred approach that the apprentices were accustomed to. It removed all the structure from the learning environment and left the students feeling lost and confused. In the time scale available for this study, it became clear that the students could not adapt to this new approach. A good constructivist approach is based: "*...on active learners constructing and reconstructing their own ideas, taking responsibility for their learning in ways they know they can do, being self determining within a caring group, negotiating with each other towards supportive ends*" (Watts, 1994 p. 52). In the case of cycle one, this did not occur as the students were not active learners nor did they take responsibility for their own learning. That is not to say that these same students, in a different context, would not have achieved good learning outcomes but in the context of the electronics and measurements labs of the phase six course, there was no evidence of the students taking responsibility for their own learning. The normal teaching methods used on the phase six course do not encourage this type of learning and it can lead to a surface learning approach instead.

Cycle two of the action research was more effective because it followed the normal teaching approach more closely, but provided more time to explore different views on what had taken place during the labs. The students responded more favourably to this approach and were able to present, and discuss, ideas that they had about the exercises. The direction of the cycles of action had changed significantly from the original idea and the model of action research, as proposed by Elliott (1991), and allowed for a shift in the plan of the research. Time was a constraint on the implementation of the investigation type approach so, with effectively only nine weeks available to carry out the action cycles of the research, it became clear that the students could not move from the teacher centred approach to the more self directed approach. Elliott (1991, p. 76) comments that: "*As a result the general idea of what the problem is, and what needs to be done about it, may have to be modified or changed*". The process of changing to the investigation method needed time and attempting to do this, in the time scale of the phase six course, was not successful.

With only one cycle of the discussion type approach undertaken, it is difficult to be definitive about the improvements that occurred in the labs. It is clear that it was more effective than the investigation type approach but how much more effective it was in comparison to the normal methods employed in the labs, is difficult to quantify. My own observations, recorded in the research journal, would indicate that there was an improvement over the usual lab methods. The comments made by the students in the individual interviews also indicate that they learned from the discussions after the exercises. The response to question 14 on the questionnaire showed that they could establish the links between the theory and the exercises.

There were two other conclusions that can be drawn from this study. The first is that the students are very examination focused, and the second is the importance of the relevance of the topics on the course to what they do in the work place. Both of these areas are linked to the motivation of the students and have been prominent in the data collected during this study. To adapt to new learning styles the students need to be motivated to go beyond the surface learning approach. Within the framework of the current phase six curriculum, this is very difficult to achieve. Sneyd (2005, p.152) commenting on the function of the school for the learning of apprentices states: "*If the school is to encourage the students intrinsic interest in learning then the curriculum content must be relevant to the students needs and the learner in turn will develop autonomy*". At the moment, the data in this study indicates that the students do not regard the topics in the labs as being very relevant to their normal work and that this can lead to a lack of interest in the labs.

6.4 Benefits of the study to the students

A constructivist approach to learning is about allowing the students to construct their own knowledge through new experiences and interactions with others. It is not a simple teaching method but a way of allowing students to have some control over their own learning. By using a constructivist approach it was hoped to give the students the opportunity to see how they could direct and control their own learning, not just in the phase six course but beyond the term of apprenticeship. Being able to direct their own learning is essential in an era where craft workers need to update themselves with new technology and practices (Harford, 2005). Education does not cease once the students complete the apprenticeship. They will go on learning many different things after they qualify as craft workers. Dewey (1897) stated that: "*...education, therefore, is a process of living and not a preparation for future living*". The need to be able to recognise and use different styles of learning is important. By using a constructivist approach I had hoped that the students would recognise this and engage more effectively with the lab topics. While cycle one was not effective in this, cycle two did encourage the students to become more involved. Not all the students in the research group, however, participated fully in the discussions. I still need to make more changes to the way I deliver the labs to improve the learning opportunities further and engage all the students in the process.

By using the discussions after the exercises it enabled the students to start thinking more about the purpose of the exercises, rather than just simply carry them out without any obvious aims in mind. It was this process of strengthening the links between the exercises and the underlying theory that I was attempting to engage the students in. Rather than simply memorise a formula, for example, it was a way of understanding why the formula was there in the first place. It was a way of gaining deeper understanding. The benefit to the students was to see that linking different parts of a topic together, could enable them to see the overall context of what they were looking at and gain a deeper understanding rather than just a surface learning approach.

6.5 Benefits to myself

The original aim of the study was to improve the effectiveness of the two labs. As the study progressed it became clear that I could not be unaffected by what was taking place. I was a central part of the research and what I did had a large impact on how the study progressed and this is an essential part of action research. It is what McNiff (2002) calls learning in and through action and reflection. By undertaking this study I have learned that the way I teach can be improved by making changes. The changes do not have to be dramatic, but they can have a large impact on the students. I have also become more aware of how the students feel about the phase six course and how it affects them. They are real people and what I do in class can assist or hinder their learning. It is a position of responsibility and one that I have come to take seriously. I did not find the research easy to implement. The students found it confusing, and I found it frustrating when they could not engage with the methods of cycle one, but this was part of the learning process for me. I have learned that what I expect students to do does not necessarily happen. Students have their own expectations and they do not always coincide with mine. At the end of cycle one, I was faced with the dilemma of what to do next. The reflections and choices I made determined the direction for cycle two. I could have made other choices but I believe the direction taken was a reasonable balance between using a constructivist approach and using the usual lab format.

6.6 Benefits to the Department

This study has shown that difficulties exist with the present situation in the two labs, more so for the measurements than the electronics. By sharing this information within the department, an awareness can be created with all the lecturers who deliver the lab classes. There is a great willingness within our department to tackle issues that impact on student learning. Creating this awareness of the depth of feeling, that the students have about the labs, is the first step in the process of bringing about change. Once the problem is recognised then it can be tackled. The problems of resources for the labs and the layout of the labs are ones that are being tackled by the department by securing more resources for the labs. Even small changes can be used to improve the environment in which the students have to work. The teaching methods used in the labs is a more difficult issue but one that requires reviewing. By using studies such as this, the benefits to the students can be highlighted. Any improvements in the effectiveness of the labs will have an immediate benefit for the students. For the department of Electrical Services Engineering, the benefits will be in knowing that the students are being provided with the best opportunities for learning.

6.7 Benefits to Apprenticeship

The apprentices responded to the questionnaire and raised some concerns about the labs. The main issues were the teaching methods used, the equipment, and the relevance of the topics covered in the labs. The teaching methods used on the phase six course follow a very traditional teacher centred approach. By using a more constructivist approach, not just in the labs but also the theory classes, then a greater emphasis can be placed on the students to take responsibility for their learning. If students are shown to learn effectively by more student centred approaches, then changes can be made to the delivery of classes in both phase four and phase six. While the end of term examination system dominates the apprenticeship scheme, this will be a struggle to introduce. The assessment of the apprenticeship scheme is coming up for review, and our department will be submitting proposals for assessment methods that will encourage deeper learning.

6.8 Recommendations

This study has shown that a constructivist approach can be used in the labs provided that, initially, it is not too heavily dependent on self-directed learning. It has also been shown that a short time scale for implementation is difficult for the students. Bearing these points in mind, the recommendations for improving the effectiveness of the labs are:

- Introduce a constructivist approach into phase four labs before phase six.
  Since it takes time to adapt to new methods of teaching, it would be more beneficial to students to be exposed to these methods earlier in the apprenticeship.

- Use a constructivist approach in other subjects.
  By using a constructivist approach in only one subject, the students tend to see it as something that is not a standard way of learning. By using the approach in other subjects they will see it as relevant to all their learning needs. Over time we can move away from the teacher centred approach.

- Secure more resources for the measurements lab to enable students to work in pairs.
  The students have voiced their preference for working in pairs and this is an area our department can deal with effectively.

- In the longer term, change the assessment of phase four and six away from end of term examinations to more continuous assessment.
  This will have the effect of doing away with the examination focus of the present system. This can only be done by changes to the syllabus in consultation with FÁS, the employers, trade unions, Department of Education & Science, Department of Enterprise, Trade and Employment and the Institutes of Technology, who together make up the partnership that organises the apprenticeship in Ireland. By introducing assessment into the labs the students would see them as being an integral part of the course.

- Change the topics covered in the labs so that they are as relevant as possible to the majority of students.

Concentrating on specialised topics in the labs has the effect of removing the relevance to the students normal work activities. Relevance has been shown to be strongly linked to motivation.

6.9 Summary

I set out at the start of this study to use a constructivist approach in an attempt to improve the effectiveness of the two labs. What appeared to be a straightforward exercise turned into something far more complex, and confusing, for the students and myself as researcher-practitioner. Having studied exactly what a constructivist approach is and possible ways of implementing the approach, I felt ready to tackle the situation. The students, however, were far from ready to tackle the situation. The process of action research involves other partners and in this study, the students were part of the partnership in using the constructivist approach. While I understood what I was attempting, I had failed to communicate this effectively to the students. Instead of a gradual introduction to the new learning approach, I had made them jump in at the 'deep end'. I can now realise that in the time scale we had, it was optimistic to have expected anything other than what actually occurred. This was part of the learning process for me and it is has taught me to be more respectful to the students' situation in the labs. I have learned also to appreciate the students' position in an environment over which they have no control. The students also learned that there are different ways of learning. This first introduction to constructivism was not the easiest for them, but the majority did agree, that they had learned from the experience. This learning in difficult situations is stressed by McNiff (2002, p.90) when she says: "*Learning from processes where things do not go right is as valuable as when they do*". I learned from the process but I am left with the feeling that there was so much more that I could and should have achieved. Perhaps my expectations were too high, but I am now more determined than ever to carry on trying new approaches in the labs until I feel that I have achieved what I set out to do. As yet, I do not have definite answers about what is the best approach to use but I am more aware of the possibilities. Fullan (1993) describes change as being a journey, not a blueprint. As yet, I do not have a blueprint but this study has shown me what direction I need to take on that journey of change.

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APPENDIX A

Questionnaire for Phase Six Electrical Apprentices

This questionnaire is purely voluntary and is anonymous, but I would like your co-operation in answering some questions about the Measurements and Electronics laboratory classes.

Please DO NOT write your name or class on this questionnaire.

Four general questions first. Please tick the appropriate box.

Question 1

What was your highest educational qualification at the start of your apprenticeship?

Junior Certificate	Leaving Certificate	Applied Leaving Certificate	Other	*If other please state type:*
☐	☐	☐	☐	______

Question 2

What age were you at the start of this present phase six course?

18 - 21	22 - 25	26 - 29	30 or over
☐	☐	☐	☐

Question 3

What centre did you attend for your phase four course?

DIT Kevin St.	ESB Centre.	Other Institute of Technology	
☐	☐	☐	***Please state name of Institute*** ______

Question 4

What is the main type of work activity carried out by your employer?

Domestic house wiring	Commercial/ industrial wiring	Electrical maintenance	Lift installations	High voltage work	Other ***please state type:***
☐	☐	☐	☐	☐	______

APPENDIX A (contd)

These next questions relate specifically to the Measurements and Electronics Labs.

Please tick one box that closely matches your attitude to the statements below, for each lab.

		Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Question 5 I find the topics covered in the lab relevant to my work	**Electronics Lab**					
	Measurements lab					
Question 6 I find the experiments covered in the lab interesting.	**Electronics Lab**					
	Measurements lab					
Question 7 I understand the reasons why I carry out the experiments in the lab.	**Electronics Lab**					
	Measurements lab					
Question 8 I understand the principles of the experiments carried out in the lab.	**Electronics Lab**					
	Measurements lab					
Question 9 I like working as part of a group.	**Electronics Lab**					
	Measurements lab					
Question 10 I find I have enough time in the lab to finish the experiments.	**Electronics Lab**					
	Measurements lab					
Question 11 I find the layout of the lab is helpful in carrying out the experiments.	**Electronics Lab**					
	Measurements lab					
Question 12 I find connecting up test instruments straightforward.	**Electronics Lab**					
	Measurements lab					

APPENDIX A (contd)

		Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Question 13 I find the instructions used for carrying out the experiments helpful.	**Electronics Lab**	☐	☐	☐	☐	☐
	Measurements lab	☐	☐	☐	☐	☐
Question 14 I can see the links between the experiments and the theory.	**Electronics Lab**	☐	☐	☐	☐	☐
	Measurements lab	☐	☐	☐	☐	☐
Question 15 I do not see a need for carrying out the experiments.	**Electronics Lab**	☐	☐	☐	☐	☐
	Measurements lab	☐	☐	☐	☐	☐
Question 16 I feel I learned from carrying out the experiments.	**Electronics Lab**	☐	☐	☐	☐	☐
	Measurements lab	☐	☐	☐	☐	☐
Please state what you like most about the lab.	**Electronics Lab**	------------------------				
	Measurements lab	------------------------				
Please state what you like least about the lab.	**Electronics Lab**	------------------------				
	Measurements lab	------------------------				
Do you have any suggestions about improving the lab?						
Any other comments?						

Thank you for taking the time to complete this questionnaire.
Frank Ashworth,
Electrical Services Engineering Dept.

APPENDIX B

Letter of Permission.

Mr. Kevin O'Connell,
Head of Dept.,
Electrical Services Engineering Dept.
DIT, Kevin St.

Dear Kevin,

As part of the MA program in Third Level Learning and Teaching, I wish to carry out an action research study on the electronics and measurements laboratories for phase six electrical apprentices. I would like to have your permission to carry out this research study with one group of apprentices for the two laboratories.

The research will focus on using a constructivist approach for running the labs. This will involve getting the students to carry out small-scale investigations into the principles behind the experiments normally carried out in the labs. The topics of the investigations will be in line with that as stated by FÁS in the phase six syllabus. I undertake to ensure that the group involved in the research study will not be disadvantaged in relation to their peers and that all necessary precautions are taken to ensure that all the objectives of the lab are met.
The research methods used will be:

- Questionnaires to all phase six groups
- End of class questionnaires for the measurements and electronics labs
- Semi structured interviews with four students from the study group
- Comparison of end of term examination results
- Research diary

The research will follow the ethical standards as stated by the DIT Ethics Committee. All students involved in the research will be briefed on the aims and methods of the research and of their right to withdraw at any time. Confidentiality and anonymity will be maintained throughout the study.

Thank you for your co-operation.

Francis Ashworth	Kevin O'Connell. Head of Dept.
Signature: ____________	Signature: ____________
Date: ____________	Date: ____________

APPENDIX C

Letter of Consent

January 2005

Dear Student,

As part of a Masters program in Third Level Learning and teaching I will be undertaking a form of action research into the running of the Measurements and Electronics laboratories.

The aim of the research is to see if the effectiveness of the laboratories can be improved, by trying out a new approach. This will involve four groups of four students carrying out small-scale investigations into various topics as outlined by FÁS in the phase six syllabus.

To do this I need your consent and co-operation. I would like to assure you that being part of this research will not in any way put you at a disadvantage to your peers in the other groups. The means of collecting data will be by means of questionnaires, semi-structured interviews with four students from the group and a research diary. Your anonymity will be observed at all times and data collected will be used strictly for the purposes of writing up the research study. You have the right to read any transcripts of data you have contributed to. Your participation is voluntary and you may withdraw from it at any stage.

I should also stress that I will not in any way be involved in any assessments towards your phase six examinations.

Thank you for your co-operation.

Francis Ashworth.

APPENDIX D

Lab Feedback Sheet

Please answer the following questions about to-days session:

	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
I understood the aim of today's session.	☐	☐	☐	☐	☐
I feel I have made progress in achieving the aim of the session.	☐	☐	☐	☐	☐
I am confused about what I am expected to do.	☐	☐	☐	☐	☐
I understand what I have to do but not how to do it.	☐	☐	☐	☐	☐
I feel confident that I have achieved the aims of the session.	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
Are there any aspects of to-days session that you did not like?					
Any other comments on the lab sessions?					

APPENDIX E

Problem Sheet

Phase Six

Measurements Lab

Three phase voltages

An electrician has been called into a small factory to sort out a problem with the lighting. It has been noticed that when certain sets of lights are turned on that other lights go dim. At other times some sets of lights seem to get brighter. After checking all the circuit breakers and the voltages at the distribution board the electrician could find no obvious fault. The electrician has now stopped to consider his next move.

Using your knowledge of the theory of three-phase systems draw up a plan that the electrician should now follow to lead to the identification of the fault or faults.

The plan should list what checks the electrician should make. You must state why the checks should be made and what the expected outcome should be.

If you make any statements about three phase theory then you must justify your statement by practical experimentation.

You may use sources of information such as your own notes, text books and handouts.

APPENDIX F

Ethics Statement

As part of a Masters program in Third Level Learning and Teaching I will be carrying out a form of action research into the delivery of the Measurements and Electronics laboratories with a group of phase six electrical apprentices.

As a lecturer in the Electrical Services Engineering department of the DIT, I undertake to carry out this research within the guidelines of the ethics committee of the DIT. As I am in a position of responsibility and trust, I will ensure that none of the students involved in the research will be placed at a disadvantage to their peers because of the research and I am also aware that I have the power to influence the students.

The students will be fully aware of the research and its purpose. I will ask for their permission in writing before the research commences. I will also obtain the permission of the head of department in writing. All data will be collected openly and with the full consent of the students involved. The anonymity of students involved will be guaranteed at all times. Any information collected will remain confidential and will be used only for the purposes of writing up the research. The results of the research will be reported honestly and with integrity.

The rights of the students involved will be respected at all times. The students have the right to withdraw from the research at any time. The impact of the research on normal class work will be kept to a minimum. The work of all those involved in this study will be acknowledged fully. Any recordings made during the research will not be released to others except with the written permission of those involved.

Francis Ashworth
December 2004

APPENDIX G

Aims of Practical Work

Kerr (1963) carried out a survey of science teachers' attitudes to practical work, and published 10 aims for practical work:

1. to encourage accurate observation and careful observation.
2. to promote simple, common-sense, scientific methods of thoughts.
3. to develop manipulative skills.
4. to give training in problem-solving.
5. to fit the requirements of practical examinations regulations.
6. to elucidate the theoretical work so as to aid comprehension.
7. to verify facts and principles already taught.
8. to be an integral part of the process of finding facts by investigation and arriving at principles.
9. to arouse and maintain interest in the subject.
10. to make biological, chemical and physical phenomena more real through actual experience.

11. As a creative activity
12. To help remember facts and principles
13. To indicate the industrial aspects of science
14. To be able to comprehend and carry out instructions
15. To develop self-reliance
16. To develop an ability to communicate
17. To develop an ability to cooperate
18. To develop certain disciplined attitudes
19. To develop a critical attitude
20. To give experience in standard techniques

10 addition aims by Beatty and Woolnough (1982)

APPENDIX H

Interview Questions

Semi-structured Interview

Phase Six research Group

10-03-2005

Q1	Why do you think we carry out lab work?
Q2	Do you feel you have learned anything from the labs?
Q3	How did this learning take place?
Q4	We started by trying to solve problems in the lab. How do you feel about this method?
Q5	Did you find the discussions about the results of the exercises useful?
Q6	If you could change anything in the labs, what would it be?
Q7	Do you feel the labs met you expectation?

APPENDIX I

Transcript of individual interviews.

No. 1

Lecturer: Right, the recorder is on, so today's the 10^{th} March 2005, so this is Frank Ashworth here and I've got student 1 with me, and I'm going to ask him a few questions about the lab work over the last 8 or 9 weeks. Right, Student 1, If I go through the sheet that you have and I'll ask you the first question. Why do you think we carry out lab work?

Student 1: Em, Actual experiments in the lab like, (yes) em, I don't know, I suppose if it ever comes up in your day to day work, you know how to do it. You would be comfortable in doing it.

Lecturer: Right. Anything else you can think of.

Student 1: That would be the main reason I suppose. Or to see how you can apply the actual theoretical part of things to practical.

Lecturer: Yeah, that's fine then. Moving on to the second question. Do you feel that you have learned anything from the labs?

Student 1: I suppose we learned how to do what we were doing, but as far as doing stuff outside of work, outside of here, it wouldn't come in, you wouldn't use it.

Lecturer: You don't see it as being relevant to your actual work.

Student 1: No, not really.

Lecturer: OK, so if you did learn something from the labs, how did you- how did this learning take place?

Student 1: How did it take place?

Lecturer: Yes, how did you learn in other words.

Student 1: Through carrying out the experiments.

Lecturer: Right, through the practical aspect of it, was it?

Student 1: I find the practical aspect better than the theoretical.

Lecturer: Yeah,-

Student 1: To actually understand it, like.

Lecturer: So, was it the actual connecting up or looking at the results from it.

Student 1: Ah no, connecting it up, yeah well, connecting it up obviously, so it actually works, but the actual- seeing the results and stuff like that.

Lecturer: Right, so we'll move on then. We started by trying to solve problems in the lab, I gave you a sheet with problems on, how did you find that method?

Student 1: It was alright. We were split up into different groups weren't we?

Lecturer: Yes.

Student 1: Four different groups. It was ok.

Lecturer: I mean, do you think you learned anything from that?

Student 1: Em, not really. It didn't go too well, that part of it.

Lecturer: Right, ok.

Student 1: In all honesty.

Lecturer: Ok, what did you find that didn't work with that. What did you find difficult?

Student 1: I don't know. There was a lot of messing going on. There wasn't much team work or anything like.

Lecturer: That's ok. Then did you find the discussions about the results of the exercises useful?

Student 1: Er yeah, yeah.

Lecturer: In what way?

Student 1: Well it was explained to us then, like you know what I mean. People started to get a bit more interested because they actually knew- had some idea of what was going on so.

Lecturer: Right ok. If you could change anything in the labs, what would it be? In other words if you wanted to improve something?

Student 1: Er, I don't know about that. I don't know what I'd change like, if I'd change anything.

Lecturer: So do you feel the labs met your expectations?

Student 1: Yeah, ah yeah.

Lecturer: So you actually got something out of-

Student 1: Ah yeah.

Lecturer: Are there any other comments you want to make about the labs and what we were trying to do?

Student 1: No, I was happy with it like.

Lecturer: So you are fairly ok with the labs.

Student 1: Yeah, Yeah.

Lecturer: Ok.

Student 1: No problem.

Lecturer: That's fine then, thank you very much.

No. 2

Lecturer: So today is the 10th March, 2005 and I have with me student 2 and we are going to go through the questions about the lab work. So question one then, why do you think we carry out lab work?

Student 2: Basically just to put the theory into practice to see how it works. Trying to make it simpler for people to understand.

Lecturer: Right.

Student 2: And get- give a better understanding of the actual theory.

Lecturer: Right, ok. Ah, the next question then. Do you feel you have learned anything from the labs over the last nine weeks?

Student 2: Bits and pieces. Personally I don't like the way it's done. I prefer more writing on the board, taking it down and explaining things. I don't really go that fast.

Lecturer: Right.

Student 2: Just like that. I don't particularly learn much from sitting there. I get bored.

Lecturer: You mean more tutorial-

Student 2: Yeah, more- yeah. More structure if you know what I mean.

Lecturer: Yeah. So the next question is basically, if you did learn something, how did this learning take place?

Student 2: More from what you were just saying or from what someone else was saying, not from actually doing the bits and pieces, because if you are working with four people, usually you find that some, one person takes over, so they get more from the actual exercise than I would. I wouldn't be one of those people that would sit there and start grabbing things.

Lecturer: So you don't think you particularly feel you learn a lot from connecting up the-

Student 2: This is just from me, I don't-

Lecturer: Yes, just yourself. Right, ok. We started off the course by trying to solve problems in the labs, so I gave you problems off the sheet so how do you feel about that method?

Student 2: Again, if you are left to your own devices, it's hard because you haven't done some of the stuff and then trying to find it even though it tells you in the regs and all that, it doesn't tell you simply what to do. Like, you kind of do need a bit of structure towards, like you know, pushing the light the right direction but I can see the thing right, but if you just gave a little bit of information and then let you go off. That kind of works.

Lecturer: Did you feel this worked for you?

Student 2: Kind of, yeah, just with the help of the other lads, so because as I said I don't particularly do well just pottering along by myself, I get lost or distracted, but just with other people when they were giving me their inputs into things, that's the way I learn. I listen more.

Lecturer: Yeah, ok, so moving on then, you said, eh, did you find the discussions about the results of the exercises useful?

Student 2: Yeah, because if you got it wrong you knew exactly where you went wrong, basically and it's a nice basis to talk about it and then you're able to say exactly, but I got this, so why, and, eh, you basically learn by your mistakes.

Lecturer: Would you say that was more useful than the actual carrying out of the experiments?

Student 2: You more or less learn- most people seem to learn by their mistakes. You learn more from your mistakes than you actually would from just being told.

Lecturer: Right, ok. If you could change anything in the lab, what would it be?

Student 2: Just a bit more structure to it, like, a bit more writing on the board, taking a bit more notes.

Lecturer: So again more combination of theory and –

Student 2: Basically what you were doing and then maybe a bit more writing, just combine the two of them.

Lecturer: Right, ok. And finally then do you feel the labs met your expectations?

Student 2: I didn't know what to expect from the start, so I can't say yeah. But yeah it was good, like, at the start I was a bit bored because I basically didn't see what the point was of sitting there. Open up a transformer thing when you could explain it to me and I would probably get it. But, em , I actually definitely saw the benefit towards the end because you are able to do it in the experiment. And even if the other teacher said that thing that it works. You done the experiment to show that no, it doesn't work. It's nice to have the experiment there and measurements like you to show what someone says.

Lecturer: Do you have any other comments about the lab, again thinking back over the last nine weeks.

Student 2: Other than what I said there like em, no, not really. Maybe not so big groups, four doesn't, personal opinion, doesn't seem to work, because as I say. Usually you have one or two kind of strong opinions in the group and they kinda go off and leave the two other lads to sit back and just take down what they are after doing, so it's not too beneficial for the two lads who are quiet. Two seems to work. You have to kind of mix and match to see who is working with who.

Lecturer: Yeah, that's it then. Thank very much.

No. 3

Lecturer: So, the recorder is on. Again it is the 19th March and I have student 3 with me and we are going to run through the questions about the lab work. So the first question was then, how do you think we- sorry, why do you think we carry out lab work?

Student 3: To put what we learned in theory in the class room, to show how exactly it works, like.

Lecturer: Right, OK. Is that the only reason?

Student 3: Well it gives you a bit of knowledge about it as well, like, transformers and all that like because the majority of us would never even have seen a transformer, a C.T.(*Current Transformer)* or anything like that ,you know. I would never have seen them.

Lecturer: They're not the kind of thing you see as part of your normal work?

Student 3: No, definitely not. The same with the little electronics board and all that, like, you wouldn't never be touching something like that at work.

Lecturer: Yeah, so again it's not directly relevant to the kind of work you do.

Student 3: Well, it wouldn't be relevant but it's nice to know, you know, like that, to have a little insight into it.

Lecturer: Fair enough. Then do you feel you have learned anything from the labs over the last nine weeks.

Student 3: Ah, I did yeah. The electronics like and the, eh, what was it.. the machine that shows the waves

Lecturer: The oscilloscope

Student 3: The oscilloscope, and that like eh, we were in the class and you were showing us the different output waveforms for the eh- the one that stuck in me head was the UJT, you know the eh, the little sawtooth and the eh, pulse lights. We done that in the class, like, but so fast that we didn't get to grasp any of it, you know like that, but you see it on the oscilloscope and you see it all working, like, it makes that bit more sense like.

Lecturer: That's good, so related to that then, how do you think this learning took place?

Student 3: Em, well like anything, if you just look at, read something, if you read something you're only going to pick up half of it, but if you actually do it, like, you'll pick up 80 to 90% of it, you know like that.

Lecturer: Right, ok. Right, so we started off by trying to solve problems in the lab. I gave you the sheet with problems on. So how do you feel about that method?

Student 3: Yeah, Well it was good, it was alright like but again, like, we didn't know a whole lot about it, to be- to be, like we didn't really know what to be looking for, you know like that. To solve some of the problems like. You know what I mean, em, like remember the current in the neutral, the star delta and all that like, I would never have- I wouldn't have known, I didn't know on the like, what to be doing, you know.

Lecturer: Do you feel you got anything out of that method?

Student 3: I did yeah. Because we had to, we ended up- well you showed us how to connect up star delta and how to calculate the current in the neutral and all that and we could learn that in the class as well, so it is relevant to the exam, you know.

Lecturer: Right. Did you find the discussions about the results of the exercises useful?

Student 3: Yeah, eh, one that would have been most useful would have been when we were doing the transformers on the power losses. Because in the class I couldn't grasp the, eh, copper losses. You know the way it's the square of the current, I couldn't grasp that in the class, but then we done it in the transformers, like eh, we seen it like, it just sank in, like you know what I mean.

Lecturer: So if you could change anything in the labs what would it be?

Student 3: Em. Probably the way it's in big groups, especially in the measurements lab. Because there's too much talking going on, like you know what I mean. You know what I mean. You get two groups of eight people and.. or even four groups of four like, if it was split down probably into groups of two or something. Because if they get- there's more talking going on than anything else you know.

Lecturer: So do you feel the labs met your expectations?

Student 3: Em, well they did yeah like but the main problem that I had with them was the talking because- because if somebody talks to be I'd just sit there and yak to them all day more or less, you know. But eh, if I was to talk like- but it did, a lot of the stuff did eh, kick in. And when I was talking to the lads outside they were saying, em, about the class you just done there, that in that class, one or two of them were saying that they learned more in that class than they did in the past ten weeks in electronics.

Lecturer: Right

Student 3: You know.

Lecturer: Ok. So you feel you've achieved something then.

Student 3: Oh definitely yeah, I have yeah. I've benefited from them alright yeah.

Lecturer.: OK. That's it then, right. Thank you.

Student 3.: No problem

No. 4

Lecturer: So it's still the 10th of March and I've got student 4 with me now and I'm going to go through the questions for the interview about the lab work. So, Student 4, first of all why do you think we carry out the lab work?

Student 4: Well to put stuff into experiments and show people how it works so that, em obviously in em , in measurements. Also we do the circuit boards and stuff and then we go into electronics, we carry out- we see how it actually does work in operation like.

Lecturer: That's fine. And do you feel you have learned anything from the labs?

Student 4: Em, yeah, definitely, definitely learned something. I've learned a lot I suppose, em, just once again come back like, we do it in theory but obviously we do it again in practical which obviously-

Lecturer: You find that it helps to reinforce it?

Student 4: Reinforce it and I think it is far easier to learn something that is carried on physically in front of you, you see it actually happening, instead of sometimes, with theory it's different like, being able to see something done in front of you.

Lecturer: Right, so if you did learn something from the labs how did this learning take place?

Student 4: Em, If we go back to question one and two, once again it's been seen to be done in front of you, so you actually see with your eyes what is happening and I think it's very easy to understand when you're actually carrying out an experiment like that.

Lecturer: OK, so when we started off the course I gave you a sheet with problems in the lab, so how did you feel about this method?

Student 4: Em, what sort, what do you mean? Sort of problems-

Lecturer: Remember the sheets I gave you to start off with in the measurements lab and that. So we looked at problems about the completion tests. We also looked at problems about the broken neutral.

Student 4: Ah yeah, yeah. How did I feel about?

Lecturer: In other words you were given a problem rather than told to go away and just do the experiment.

Student 4: I suppose once again it comes back to fault finding. I suppose when we split up into sort of groups I suppose a couple of heads is better than one I suppose so em-

Lecturer: I mean, do you think that method worked?

Student 4: Em, I do think it works because I suppose you really have to think about it, there's a few people thinking about it, so there's different opinions and different people looking at the information. Different whatever problems we were trying to solve by ourselves, so-

Lecturer: So do you feel the discussions after the experiments about the results were useful?

Student 4: Yeah, I thought it was good to discuss the results, how you came about these results and how you found them, and what's the best way to go back and find faults. Once again there's different answers coming at you, it's different- people do it different ways, so I found it beneficial alright, yeah.

Lecturer: So if you could change anything in the lab what would it be?

Student 4: Em- em-

Lecturer: I mean thinking in terms of the way the labs are run and that. Is there something that you think should be done differently?

Student 4: Em, I think that sometimes when you come into like a group situation, the whole lot of us, and there's one person, like yourself, that's discussing a problem, I think I did myself like, and the other lads too, I tend to drift off a bit because there are so many in the group, that people shout in answers and people are getting more into it and some lads aren't sort of thing. Once you lose track of it, it's gone so I think maybe em-

Lecturer: So do you think the labs met your expectations?

Student 4: Em to be honest I didn't know what to expect once I got into the labs, em I didn't know what to expect, but I found it very beneficial, enjoyed it. I did the circuit boards before in phase four. I enjoyed it in phase four, all the- going back and doing the experiments and labs was something you've done before. I found it very good and I think it's a very good way of trying to get the results and trying to get, I suppose , the point across how things work and the operation of different things.

Lecturer: Right that seems fine then. Thank you very much.

APPENDIX J

Responses to question 17 on questionnaire

	Likes	Electronics	Measurements
1	Practical work with components/circuits	20	11
2	Relevant to theory	7	4
3	More understanding of circuits	2	2
4	Explains the course a bit better	0	2
5	Nothing	9	12
6		0	0
7		0	0
8	Teacher comment (derogatory)	0	1
9	Interesting and helpful	1	1
10	Waste of time	0	3
11	Teacher helpful	2	0
12	Experiments and teacher	2	0
13	Breakfast was next	0	1
14	Seats	8	8
15	Tables	0	1
16	Blowing things up	1	0
17	Stealing equipment	0	1
18	The end	2	1
19	Working as a group	1	1
20	Looking at all subjects	0	1
21	Learning something different	2	1
22	Interesting	3	1
23	Boring	1	0
24	Don't do it	0	3
25	Revision done instead	1	3
26		0	0
27	Explained well, good setup	1	1
28	Atmosphere	0	1
29	Relevant to job	0	3
30	Talking to mates, sleeping	3	1
31	Studying other subjects	0	1
32	Space in lab	1	2
33	Break from taking notes	0	1
34	Short Friday morning	1	0
35	No exam pressure	1	0
36		0	0
	SUM	69	68

The phrases were taken from the questionnaire sheet and the number of occurrences were recorded. These were then further analysed to give the seven categories shown in Figure 4.18

APPENDIX K

Transcript of focus group at week four

Lecturer: O.K So the recorder is on. It says it is on. *(looking at the red light on the recorder)*. Today is the 10th February 2005. And we have four people, students, present; we have student 1, 2, 3 and 4. So like I told you on the very first day, the purpose of the research which I am undertaking was to see if we used a different approach in the lab- and the idea was to use what we call a constructivist approach in where we give you an investigation where you can look up items, find out information, experiments for yourselves and reach your own conclusions. So you had some autonomy in what you actually did, so you could investigate things on your own initiative, if you like, and look up sources of information. So over the last four weeks I've been trying out this method. So what I want to try and get now is your views on what has actually happened. I mean, has it worked? Your- do you agree with the way it's run, your views of it, what we can actually do? So to start- Student 3 first, I mean what do you think of the methods that we have used for the past four weeks?

Student 3: They were alright. I thought the first one in the lab, remember the delta and the star, and connecting all that up, I didn't have a clue when I was doing it, it would have been alright if you told us when- what way to connect it up first because I didn't really understand. But I thought last week given the RCDs and that was sound.

Lecturer: So would you say you would prefer to be given the information?

Student 3: I thought none of them worked, like, you know what I mean, I didn't know, the other lads probably knew, did you notice that. I didn't know how to connect it up, you know, in star you know, going between the contactors and all that.

Lecturer: So would you prefer to be given all the circuit diagrams, rather than trying to find the information yourself.

Student 3: No, if you give us a bit of insight into it but not be given all the diagrams and that, then do it yourself and figure it out yourself, but try and give a little push along the way, know what I mean.

Lecturer: Well would you think that is what actually happened over the last four weeks?

Student 3: It did a little bit, yeah, but the first week, like, I was in over me head, you know.

Lecturer: Does anybody else have a view on that?

Student 1: I was in over me head, I hadn't a clue of what we were doing.

Lecturer: So what did you find difficult?

Student 1: All of it, more or less.

Lecturer: So you would-

Student 1: I don't understand it, how this electronics works.

Lecturer: I mean, was it a problem of the content of it, rather than what you were trying to do?- I mean, did you find it difficult to look for the information?

Student 1: Yeah that as well, like. Sure everything you did I didn't understand it at the time. Well even the way it's been taught, it would come out like this.

Lecturer: Well, so more the content that the method you are actually using.
Student 1: Yes

Lecturer: Any comments on this anybody?

Student 2: The first time we were doing it, I- , the bit we had we felt happy about, After that a bit more information and things like that would have been ok, not to be given all the information, like a little more and figure out the rest would have been grand. The rest I think is going down well so far, just be given enough information and be able to work out the rest and personally I'll be ok after that then.

Lecturer: Yes

Student 4: The theory side of it I find hard. The practical side I don't find a problem.

Lecturer: So actually carrying out the experiment would be straightforward but understanding what the experiment is trying to do would be the difficult one?

Student 2: -what each individual things that are there- that's the problem

Lecturer: So trying to relate the-

Student 3: Overall you know what it does, just the internal ones. Need more of a –

Lecturer: So would you say that connecting up circuits is ok?

Student 3: Yeah, alright at connecting up circuits but graphing some of the stuff, you know what I mean, just getting the graph of them and that-

Lecturer: So, you can use the instruments, you know what they are and how to connect-

Student 3: You need to state-, say what its doing and all that, but you still don't understand it, you just know what you told us. It does this but- you know what I mean.

Lecturer: So what about getting the information from the experiments, then, so you've connected these things up, you've got readings, what happens then? Can you understand what the readings mean or how you are suppose to use them?

Student 4: What you do depends on the experiment really, it's like, er, on doing the completion certs, we were doing tests for that. We had to look at rules and we had to ask you the max levels or whatever and if we got a reading a bit close or whatever, you know then there is a problem or whatever, like the others- like a lot of them are handy enough and straightforward but other ones are a little more different to it.

Lecturer: So it's trying to relate what you've done to the theory side of it then?

Student 4: Yes.

Lecturer: Any other comments there?

Student 3: Do you see that RCD yoke? The thing we do outside, that would be easier to relate to than the stuff we do in here, you know, know what I mean. You see it, you see it out in the field, you know what I mean. Regarding the electronics and all you wouldn't really, you know what I mean. So the little bit of knowledge you need out in the field, you'd know.

Student 1: It's nice to see the link.

Student 4: What you need to know you'd learn that on site really, what you need to do on site.

Lecturer: So if it's more work relevant then it means more to you then ?

All: Yes

Lecturer: So the electronics, can you relate them to anything.

Student 3: Not really, no.

Lecturer: So you regard them as being-

Student 3: So when we get it - We just get it to work.

Lecturer: Yes

Student 3: There's very little-

Student 1: We never need it.

Lecturer: So relevance to work would be important then, to you?

Student 3: Well it would help you, if you were doing it you would be more interested in it, it's worth it like.

Student 4: Rather than feel like - That does this - you try and like well-

Lecturer: Yeah

Student 4: It's used in this or what ever.

Student 1: You then - it's relevant to work.

Lecturer: So what I am going to try this week is to try and give you a bit more detail on the experiments, carrying out the experiments, then see what you make of the results that you get from them. So in the measurements lab we are going to be looking at the transformer. So when we do the tests, its trying to relate what the tests actually mean in practice. Like what would you do with the results, how would you know if the results are good, bad or within parameters? So we are going to try and run it go along that way and see if these things make more sense to you. Or you can actually understand the theory behind them, while you are actually doing them. So would-

Student 3: If you give us the information to us, told how to do it first, and then let us try it, then you would understand it more-

Student 4: - whereas if you are sitting there and don't know what to do-

Lecturer: Yeah, when I give you a handout the object is in fact to let you investigate, can you find the information to solve the particular that we are asking, but is that a method you like doing?

Student 3: We spend an awful lot –

Student 4: In respect of what, the electronics one, you mean the lab-

Lecturer: Either lab.

Student 3: Well in the electronics you don't really know a lot about it, you know what I mean. In the electronics - You don't really know a lot about it.

Student 1: In the electronics lab, I mean if you try to find a voltage between this and that, and you come to me in the lab, you kind of know what you are doing, but as far as the components go I really haven't really got a breeze, you know what I mean. If only someone here says why you are doing it.

Lecturer: Yeah, so you won't –

Student 1: You're not at it every day so you wouldn't really know a lot. All the stuff you learned a year and a half ago, its all gone out of your head

Lecturer: Yeah. Right, that's fine, unless you have any other comments. I just wanted to get a feeling of how you see the lab so far, and I'm going to try and change the emphasis a little bit, and see how that works out, and hopefully get your feedback a bit later on. So, thank you for your time.

ALL

No problem

Main Themes:

Understanding the individual components of the electronic circuits

Relevance to work

Relating exercises to theory

Lost when trying investigation

Forgotten phase four theory (18 months ago)